BARRETT -
HAMILTON

BRITISH
MAMMALS

RODENTIA

PART XIV.—August 1913 Price 2s. 6d. net.

A HISTORY OF BRITISH MAMMALS

BY

GERALD E. H. BARRETT-HAMILTON

B.A. (CANTAB.), M.R.I.A., F.Z.S.

WITH TWENTY-SEVEN FULL-PAGE PLATES IN COLOUR, FIFTY-FOUR IN BLACK AND WHITE, AND UPWARDS OF TWO HUNDRED AND FIFTY SMALLER ILLUSTRATIONS

DRAWN BY

EDWARD A. WILSON

B.A., M.B. (CANTAB.)

GURNEY AND JACKSON

33 PATERNOSTER ROW, LONDON, E.C.

1913

In Preparation

A NEW AND REVISED EDITION OF
YARRELL, NEWTON, AND SAUNDERS'

HISTORY OF BRITISH BIRDS

EDITED BY

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Keeper of the Natural History Department, The Royal Scottish Museum; Member of the British Association Committee on the Migration of Birds as Observed on the British and Irish Coasts; Corresponding Fellow of the American Ornithologists' Union; Correspondirender Mitglied des Ornithologischen Vereins in Wien; Membre Honoraire du Bureau Central Ornithologique Hongrois; Member of the British Ornithologists' Union, etc.

ILLUSTRATED BY ORIGINAL COLOURED PLATES OF EACH SPECIES SPECIALLY EXECUTED BY

MISS LILIAN MEDLAND

THE publication of Yarrell's "History of British Birds" was commenced in 1837 and completed in 1843. Its outstanding merits were at once recognised, and a Second Edition was called for in 1845, followed by a third in 1856.

From the issue of the Original Edition down to the present day, Yarrell's "History of British Birds" has generally and deservedly been regarded as the standard authority on British ornithology.

In the year 1871 a Fourth Edition was begun, under the masterly editorship of Professor Newton—the greatest British ornithologist of all time. Unfortunately Professor Newton's official engagements at the University of Cambridge only allowed him to complete the first two volumes; and in 1882 Mr Howard Saunders was selected to edit the remaining volumes, a task which he successfully accomplished to the entire satisfaction of ornithologists in 1885.

The many excellences of this last edition advanced the work more than ever in the public and in scientific favour. To its stimulating influence is to be mainly attributed the marvellous and unprecedented activity which has resulted in those extraordinary advances made in all branches of British ornithology during recent years—advances which have rendered it essential that a new work based upon this classical and comprehensive foundation should be issued.

During the period alluded to, a considerable number of new and interesting species have been added to our avifauna. The

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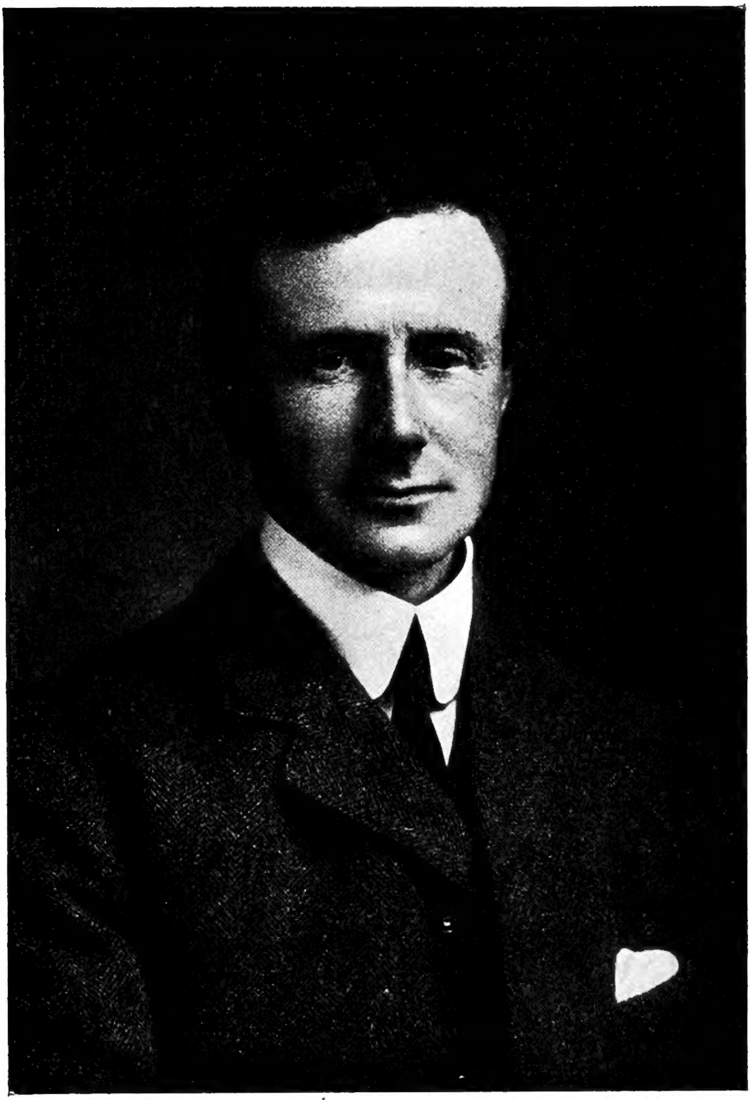
The English local names have been revised in part by Mr W. W. Skeat, M.A. (assisted by the late Professor W. W. Skeat), and in part by Mr C. M. Drennan, M.A. Lond., late Scholar Emm. Coll. Camb.; the Celtic and Gaelic names by Dr E. S. Quiggin, M.A., Ph.D., Fellow and Lecturer in Modern Languages and Celtic of Gonville and Caius College, Cambridge; while a list of Scottish Gaelic names has been supplied by Mr C. H. Alston. Valuable assistance has been rendered by Mr M. A. C. Hinton regarding extinct Mammals. Much information has been taken from Mr G. S. Miller's recently published "Catalogue of the Mammals of Western Europe," the use of the MS. and proofs of which before publication was kindly permitted by the Trustees of the British Museum of Natural History.

ILLUSTRATIONS

FULL-PAGE (*Coloured and Black and White*).

FIGURES IN TEXT.



Yours faithfully.
Edward. A. Wilson.
1910.

EDWARD ADRIAN WILSON

AN APPRECIATION

WHILE the whole civilised world mourns for the gallant men who perished during the British Antarctic Expedition, the author and publishers of *A History of British Mammals* especially feel the loss of one who was not the least heroic participator in that glorious misadventure, Dr Edward Adrian Wilson, our artist.

Encircled as his name is by the halo of a rare achievement, he represents to those who did not know him personally, something removed above the humdrum existence of ordinary men. To us he was a comrade, workmate, warm-hearted friend of very visible and entirely human flesh and blood.

On the return of Captain Scott's first Antarctic Expedition in the *Discovery* in 1904, Wilson, hitherto practically unknown either as artist or zoologist, attracted much attention by his marvellous rendering of Antarctic scenery and animal life. His pictures of the seals and penguins brought those, at that time almost apocryphal creatures, before the public with a vigour, fidelity of attitude, and brilliancy of colouring never, we believe, previously attained.

In admiration of these paintings we opened up negotiations with the object of securing his services for our illustrations, negotiations which were not hindered by the fact that author and artist had at Cambridge attended the same lectures, frequented the same laboratories, and finished equal in the Tripos of 1894. To complete the parallel, both were candidates for appointment

to the scientific staff of Scott's first Antarctic Expedition (1901-4), for which one alone could be accepted. To the rejected applicant fell the consolation of compiling for the use of his successful "rival" the chapter on seals in the *Antarctic Manual* (1901).

We considered ourselves exceptionally fortunate when Wilson found himself able to undertake the work, and he threw himself into it with all the ardour and enthusiasm of the simple-minded naturalist that he was. The "free hand," so often longed for, so rarely permitted, was granted, the result being a long series of drawings which we contend mark a new epoch in the illustration of a British book of the present class. The only cause for regret is that the processes of reproduction have toned down Wilson's colour, always his strong point. So keen was he about his illustrations, that he made a special journey to Shetland to study whales at the whaling stations; and he confidently hoped to bring back from his long voyage to the Antarctic much new information to form the basis of further illustrations of the Cetacea.

On Wilson's second departure to the Antarctic a few drawings were still wanting to finish the scheme, and we think we may congratulate ourselves on having secured Mr Guy Dollmann, of the British Museum of Natural History, to complete the task. Mr M. A. C. Hinton has also supplied many technical drawings, his unique knowledge of the skulls and teeth of our extinct micromammalia making his work peculiarly valuable.

Of the man Wilson we say little, as he himself would undoubtedly have wished. Simplicity, straightforwardness, patience, enthusiasm, were all strong points in his character. One could not associate with him without feeling that one had gained something. While his natural breadth of mind must sometimes have revolted against the minute detail inseparable from mammalogy, he yet lavished the most careful attention on the numerous technical diagrams, to master the meaning of which meant much study on what was to him a novel subject. A dreamer of great dreams, it was sometimes necessary to call

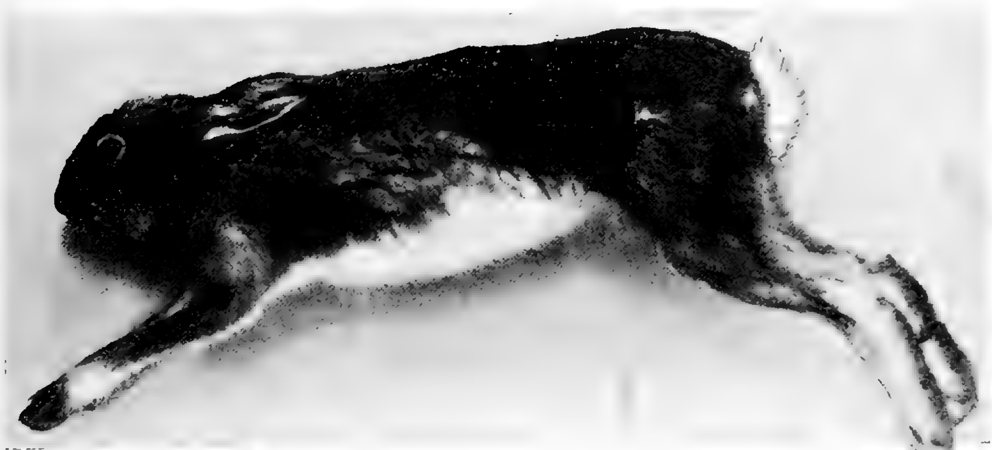
him to earth for a demonstration on murine osteology, but no man ever took criticism in better part. As a rule he forestalled it by a genial counter attack :—"You are so polite this morning, that I know you are going to tear my drawings to pieces," was his typical opening to a discussion. Like all geniuses, he was full of contradictions; a delicate man, he yet went to the Antarctic "for his health," and when asked to explain this paradox, remarked that he never felt the *joie de vivre* till he was on a sledge journey. His unselfishness resulted in his undertaking during the first expedition the odious but necessary duty of daily slaughtering a sledge-dog to be devoured by the rest of the team; it was no less characteristic of his nature to find philosophical reflections on canine psychology in that unpleasant task.

Wilson has gone! His long, lean figure will no longer stalk down the galleries of the British Museum of Natural History to a conference on Mammal illustrations, but we, his fellow-workers, will treasure his memory, proud that for a brief space he journeyed with us, lightening our labours with the encouragement of the truest good-fellowship.

GERALD E. H. BARRETT-HAMILTON.

The accompanying signed portrait was presented to the publishers by Dr Wilson on the eve of his departure to the Antarctic.

(1)



(2)

(1) BROWN HARE, subadult female, Poynetts, Buckinghamshire; (2) IRISH HARE, adult male, Kilmanock, Co. Wexford; to show differences in external appearance. (See pp. 337-338.)

Geographical variation:—As shown by the Italian and Sicilian forms, *pulcher* and *speciosus*, there is evidently a tendency to brighter tints and more striking contrasts in the south. In 1900 (see *Synonymy*), I separated the British form from *M. a. avellanarius* on the ground that, whereas each is more dully coloured than *M. pulcher*, the British, which I named *M. a. anglicus*, appears to have the upper side more brilliant, a whiter breast, and a thicker and shorter tail than the typical form. Miller, working more recently, is unable to accept this conclusion; but there is room for further study, as no series of British dormice is available for examination.

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).
MALES:—				
1. Purchased in London, 15th December 1898 (W. Dodson)	71	..	16	13
2. Honiton, Devon, 22nd August 1904 (G. C. Shortridge)	75	68	18	13
FEMALES:—				
1. Wendon Lofts, Saffron Walden, Essex, 31st May 1894	85	61	15	..
2. Colchester, Essex (G. S. Miller) . .	77	55	16	11
3 and 4. Purchased in London, 15th December 1898 (W. Dodson) . .	73 70	62 55	16 17	12 12
SEX UNCERTAIN:—				
1. (No. 99.11.27.6 of British Museum Coll.), Bedford Purlieus, Thornhaugh, Northamptonshire, 5th January 1895 (H. H. Slater); type of *M. avellanarius anglicus* . .	86	57	16	..

Skull:—Greatest length, 22·7 to 24·5; condylo-basal length, 21·8 to 23; breadth at zygomata, 13·2 to 14·4; inter-orbital breadth, 3·0 to 3·4; mastoid breadth, 11; depth of brain-case at middle, 8·0; greatest length of nasals, 6·8 to 7·2; of diastema, 6 to 6·2; of mandible, 13 to 14; of maxillary tooth-row, 4·8; of mandibular tooth-row, 4·2 to 4·4.

Weight in grammes:—Rabus (*Zool. Garten*, 1881, 321-325, translated in *Zoologist*, 1882, 161-164) found that this varies between 23 and 43. It increases during the season of activity, especially in September, and attains its maximum just before the commencement of hibernation. It then decreases,[1] a female having dropped from 37 to 26 during hibernation lasting from 19th October to 27th March, or about at the rate of 2 a month. The September increment amounted in

[1] Some naturalists have curiously supposed that both fat and weight increase during hibernation.

various seasons and individuals to from 39 to 43, 25 to 35, 24 to 37, 29 to 37, and 21 to 28.

Distinguishing characters:—The peculiar colour and the pattern of the teeth are absolute distinctions amongst British mammals.

The Common Dormouse is a timid animal of gentle disposition. Although capable of extreme activity when frightened, it is naturally of a somewhat sluggish temperament, wearing an air of lethargy until roused, and sleeping away half the year in the more or less complete torpidity of hibernation. It has thus come to be regarded as a type of drowsiness. Shakespeare makes Fabian say—"to awake your dormouse valour";[1] and in our own day it figures in Lewis Carroll's *Alice in Wonderland*.

It is most at home near the edges of dense coppices and thickets,[2] in the undergrowth of which it builds its nest; and it is in creeping about in such surroundings that it exhibits its greatest adroitness, an adroitness quite unequalled by the agile Harvest Mouse, and scarcely surpassed by the Squirrel. It does not seem to have many enemies, but Mr E. G. B. Meade-Waldo informs me that it is preyed upon by owls.[3]

It is popularly supposed to feed chiefly on hazel nuts, and its technical name, *avellanarius*,[4] is based on this belief. But it eats also wild fruits and berries,[5] acorns, seeds, grain, and certain leaves.[6]

In eating a hazel nut it removes about one-third of the

[1] *Twelfth Night*, iii., 2.

[2] Oxley Grabham has sent me a note of a remarkable habitat in Yorkshire—a plantation in the middle of a moor.

[3] The first specimen of *Dyromys milleri* (Thomas, *Ann. and Mag. Nat. Hist.*, April 1912, 394-395), a small dormouse of Central Asia, was picked up by J. H. Miller after having been dropped by a crow.

[4] From Abella, now Avella, a town in Campania, Italy, abounding in nuts, hence *Abellana nux*=the filbert. Some writers suppose that dormice are unable to open ripe hazel nuts, and in this respect experiences are contradictory.

[5] Especially of the mountain ash, when coming to eat which it may be snared with nooses (A. E. Brehm).

[6] In captivity it likes plums, apples, strawberries, and particularly cherries; in fact, all except very acid fruits, together with salad, Indian corn, almonds and nuts, but usually refuses meat, cheese, bread and milk, or eggs (Fernand Lataste, "Recherches du Zooéthique sur les Mammifères de l'ordre des Rongeurs," *Act. Soc. Linn., Bordeaux*, xl., 1887; L. E. Adams, *MS.*); lettuce, sorrel, and groundsel (Mayne Reid, *The Naturalist in Siluria*, 1889, 102).

South Orkney Grass Mice.

complete shell, but it cannot tell in advance if the kernel is sound, so that its boring operations are often abortive. In captivity it has been known to return to an empty shell and open a second hole.[1] With Barcelona nuts it gnaws through the edge of the rough circular patch and then downwards.[2] It often drinks largely, bending its head towards the water until its lips are immersed.[3]

It seems to be fond of sweet things, for more than one observer has found it devouring the "sugar" placed on a tree-trunk to attract moths,[4] and Mr E. Bidwell[5] saw one nibbling the flowers of honeysuckle to get at the nectar.

It will also consume aphides, nut-weevils, and caterpillars, and occasionally the eggs[6] of small birds; but, perhaps on account of its smaller size, it does not appear to be so much addicted to a diet of flesh or eggs as are the larger dormice of continental Europe. Retribution may sometimes overtake it when trespassing, for Mr A. H. Cocks once found one pecked to death in a thrush's nest.

Like many other rodents this mouse commonly sits on its haunches when eating, holding its food in its hands. But it will also suspend itself head downwards by means of its small but remarkably strong claws, and even feeds comfortably in that position; it can run up and down the naked bole[7] of a tree with astonishing rapidity. It is, besides, an active leaper, and springs from twig to twig for surprising distances.

The adults are almost entirely nocturnal, and rarely stir abroad until darkness is complete, but the young are both more careless and more active, and may be encountered by daylight. Comparatively few people, however, happen on one thus adventuring, and, as a rule, the first introduction to it is

1 Reid, *op. cit.*, 99.
2 Adams, *MS.*
3 H. E. Forrest, *MS.;* Robert Kerr, *Animal Kingdom*, i., 270, 1792, thought that when thirsty they "dip their fore feet, with the toes bent, into the water, and drink from them!"
4 H. Laver; R. Newstead, *Proc. Chester Soc. Nat. Sci.*, 1894, 248; J. R. B. Masefield, *MS.*
5 *Field*, 16th July 1898, 134.
6 It is sometimes found asleep on the broken or sucked eggs, but, as in the case of the Hedgehog, damage to eggs is not always intended, and C. E. Wright found one occupying a starling's nest in a hole in an oak, the eggs intact.
7 Cocks, *MS.*

more or less of a surprise. The bird's-nester finds a round structure, about three inches in diameter, resembling a wren's nest, and on his touching it there rushes out a brightly coloured mouse, which slips with amazing activity through the underwood, or finally disappears from view on the ground. The intruder may, perhaps, have chanced to find a colony of nests, from each of which an inmate issues, and in the ensuing confusion it is quite likely that the whole party will make good their escape. On the other hand, if a single individual be pursued, it is one of the easiest of wild animals to catch, since, although extremely active, it has no certain retreat at hand, and its conspicuous coloration is not a help to concealment. When captured, it is inoffensive, and very rarely attempts to bite.

When several summer nests are found in association, they are near, but not touching each other, and rarely contain more than one inhabitant, so that the Dormouse may be described as gregarious, but not entirely sociable. Many nests are without opening of any kind, although with the wall thinner at the top where the inmate is accustomed to pass in and out; others possess a distinct circular opening, especially when empty, which opening is an unusual feature so far as British mice are concerned. They are usually placed amongst brambles or blackthorn, in hedges, or even in the tops of large tufts of grass,[1] and not often at any considerable height from the ground. But where some bird's nest can be utilised, the general objection to height seems to be waived, whether for purposes of sleeping, breeding, or hibernation, and in Sussex Mr Cocks found a mouse occupying a nest, apparently of a magpie, 20 feet up in a spruce fir. More frequently an old nest of blackbird, thrush, or wood-pigeon forms a platform. Holes in trees[2] are much appreciated when available, and the artificial nesting-boxes of bird-lovers are often selected.[3] At other times more lowly and unexpected situations are selected; in June 1903 two nests were found[4] at Warn-

[1] J. Steele Elliott (*MS.*), who finds many within 2 feet of the ground.

[2] At East Grinstead, Sussex, a pair were dislodged from a woodpecker's hole; F. H. Birley, *Zoologist*, 1887, 69.

[3] When these contain a nest from which young birds have flown, it is pulled to pieces, and leaves and other materials are added (Meade-Waldo, *MS.*).

[4] J. G. Millais.

ham Pond, Sussex, in a very open situation in a bed of withies, standing in reeds and water. A furze bush often affords a convenient site, and in the Isle of Wight ivy-clothed rocks or trees, and ricks,[1] are much sought after; in other localities, the vicinity of the climbing "old man's beard,"[2] the downy seeds of which make a warm lining in autumn, or a dormitory may be formed entirely of them;[3] which shows how loosely these structures are held together. But the more usual materials are dried grass, gathered green,[4] and moss, lined with finer grass, or with warmer materials, such as sheep's wool. In Shropshire, Mr Forrest[5] has examined scores of nests all thus simply constructed. But near Shrewsbury the same writer[6] finds them never far removed from a clump of honeysuckle in autumn, when alone the dead bark can be obtained in quantity. This often provides the only material, long coarse strips externally, holding a lining of shreds; occasionally dead leaves are added, but no grass. Mr Cocks found one which, although autumnal (22nd Sept. 1903), was entirely composed of fresh green hazel leaves. The loose weaving of the nests, and the fact observed[7] in captivity that one can be put together in a single night, make it possible that several may be built by each individual in a season.

For her young the female usually prepares a special nursery. This resembles, in its materials and construction, the ordinary summer dormitory, but is larger, the diameter being about 6 inches or more;[8] it is often placed close to, although not actually on, the ground; and careless mothers may even use an ordinary dormitory for a nursery. The separate retreat of the old male is generally not far away.

Dormice are sedentary, and probably monogamous creatures; being active only during the six months of plenty, and laying up a store against their spring awakening, they have no need to wander. Mr Steele Elliott watched two pairs

[1] Capt. Henry Hadfield, in G. T. Rope, *Zoologist*, 1885, 202.
[2] *Clematis vitalba.*
[3] Adams, *MS.*
[4] A common arrangement includes four layers, *e.g.*—(1) externally a few dead leaves; (2) grass; (3) a double layer of bramble leaves; (4) a lining of fine grass.
[5] *Zoologist*, 1901, 69.
[6] *Journ. cit.*, 1902, 23.
[7] Forrest; Lataste.
[8] Adams, *MS.*

for years, and their nests were always placed within 100 yards of a previous one. Mr Forrest has observed[1] the method of building in a captive. Seizing each piece of grass by the middle in its mouth, it dived into the nest-box, and, turning over repeatedly, laid the bent round the cavity, at the same time smoothing it and rounding it outwards.

It is generally stated that there are most frequently four young, but since there are eight teats, larger numbers may be expected. A litter of seven, still blind, was found on 8th October 1912 in Mr Cocks's wood at Skirmett, Buckinghamshire,[2] and others of six[3] and five[4] have been reported; sometimes there are only two young, and probably the earlier litters are smaller than those of the late summer.

There is some dispute about the sexual season. One view is that, like hedgehogs, dormice are polyœstrous (as they certainly are in captivity), with two breeding seasons, a litter of young being born early in the summer, followed by a second in the autumn. Thus Thomas Bell[5] received, from one locality in September, an adult, one about half-grown, and three very young, which he judged to be not older than a fortnight or three weeks. Messrs Cocks and Forrest have voiced another view, namely, that autumnal litters are the rule. In this they are partially supported by Monsieur H. Gadeau de Kerville, who states that in Normandy births take place habitually in August, with, perhaps, in favourable seasons, a first litter in June. Against this, Monsieur Lataste received a Swiss female which bore young on 1st June 1882, and there are British records for various dates from the middle of May[6] to October; so that it is possible that the breeding season may last throughout the period of activity. In captivity, when

[1] *Zoologist*, 1901. [2] *MS.;* the eyes had opened by 13th October.

[3] Half-grown, near Basingstoke, Hampshire, September 1906 (Owen Jones, *Field*, 22nd September 1906, 540).

[4] In nest, Shropshire, 15th September 1903 (Forrest, *MS.*). [5] Ed. 2, 284.

[6] Wright (*MS.*, per Adams) found a litter supposed to be two or three weeks old on 2nd June 1909, *i.e.*, born 12th to 19th May, and a Northamptonshire nest containing two young on 5th June; as their eyes were open on the 11th they must have been born, according to Lataste's observations quoted below, about eighteen days earlier, or on the 24th of May. In the Forest of Guines, Pas de Calais, France, Oldfield Thomas took five blind and naked young on 20th May 1894; see Barrett-Hamilton, *Proc. Zool. Soc.* (London), 6th February 1900, 86. A midsummer instance for young with closed eyes is 26th July (Heatley Noble, *in lit.*).

the onset of hibernation is postponed, litters may be born in the winter.[1] Monsieur Lataste concludes that the period of gestation is about three weeks,[2] and since captives will pair about every ten days, and the young are independent of their mother by about the twenty-fourth day, there is plenty of time for a series of litters between May and November. To produce young in the middle of May the mice must have paired shortly after concluding their hibernation.

The young at birth have the eyes and ears closed, and are destitute of hair. One born in the cages of Monsieur Lataste, opened its eyes on about the eighteenth[3] day, and on the nineteenth moved out of the nest for the first time and began to eat. When twenty-one days old, it attained the characteristic aspect of its race. It now began to climb about its cage; on the twenty-fourth day it differed from its parents chiefly in its lesser size.

If disturbed, the female, like other mammals, will sometimes remove her young by the scruff of the neck in her mouth, and Mr Grabham has photographed one in the act; such removals are, however, believed to be of rare occurrence.

By the end of September the Dormouse becomes exceedingly fat.[4] In October or November, having built its winter or hibernating nest, and laid up a store of food either beside or in its bed, each animal retires separately, and curling itself up into a ball, with its fore paws against its cheeks and its tail wrapped round its head and back, passes into torpidity.

The winter nest is usually constructed of moss, under an accumulation of leaves, it may be 2 feet thick, and placed in a hollow of the ground protected by roots of trees or stones. It may occupy a cavity in a tree-stump, sound or rotten, but frequently lies underground.[5] Quite often the hibernaculum differs neither in structure nor situation from a summer dormi-

[1] Three young soon after Christmas, in captivity (L. A. Dunnage, *Field*, 4th February 1905, 190; see also *Field*, 8th November 1873, 485).

[2] *Op. cit.*; he states that in *Eliomys* gestation lasts twenty-two days, and œstrum recurs about every ten days.

[3] A very late date compared with a rabbit or mouse (see above, p. 211), perhaps because eyesight might lead to premature attempts to leave the nest.

[4] See above, p. 361, under *weight*.

[5] As deep as 2 feet (Frances Pitt, *MS.*). In 1904 Millais saw forty discovered amongst the fibrous roots of rhododendrons at Warnham Court, Sussex.

tory, and the torpid mice may also be found in bird-boxes, and in deserted nests of birds;[1] Mr F. W. Frohawk knew of one in mid-winter placed in an exposed alder bush. No doubt such rashness or remissness in providing for hibernation is severely punished in frosty weather.

Hibernation is profound. The animal ceases to breathe,[2] and becomes so cold and rigid that it can be rolled like a ball across a table.[3] A mild day may call it back into transient life,[4] and it will then seize the opportunity to enjoy a meal[5] before again relapsing into slumber. But, with interruptions, its sleep lasts[6] until some day in April. By the latter month it has lost much of its fat, and it then completely awakes and enters upon the habits usual to an active state of being.

A hibernating dormouse can always be aroused, and its complete awakening requires about twenty minutes. When again left alone, however, it soon relapses into lethargy; but sometimes the disturbance to its system is fatal, especially if the change be too rapid, as when heat is too suddenly applied to it. During the few days just before and after hibernation, it is in a constant state of transformation from complete torpidity[7] to the most lively activity; and if kept warm in captivity this uncertain state can be much prolonged even in winter. But whenever it falls asleep, even in summer, its temperature drops and it feels cold to the touch. Mr Forrest[8] found the temperature of summer somnolence only 80° F., as against 98° F.[9] during activity.

The fate of the last litter of young is an interesting point in the animal's economy; newly born litters may be found

1 Meade-Waldo, *MS.*; Millais.

2 As observed by Lazare Spallanzani in 1807 (ii., 216-221 and 222-236) for this species and others.

3 Douglas English, *Some Smaller British Mammals*, undated, 78.

4 5th December, dormice active (Steele Elliott, *Journ. Birmingham Nat. Hist. and Phil. Soc.*, 1896—unpaged reprint); any found in an active state during winter are instances of spasmodic awakening.

5 Hence it may defecate during hibernation (Adams).

6 One slept continuously for six months and twenty-three days; another, with one interruption only, for six months and nineteen days (Rabus, *op. cit. supra*, p. 361).

7 Gordon Dalgliesh took one "in a complete state of torpor" (*Zoologist*, 1907, 299-300) on 9th May 1907.

8 *MS.*

9 92°-94° F.—R. I. Pocock, *Encyc. Brit.*, 11th ed., art. "Hibernation," 442.

until the first week of November.[1] These would require their mother's attention so long as possibly to delay her own hibernation; hence it has been thought[2] that the members of these late broods always perish. The young certainly become lethargic more tardily than adults, and in captivity they often seem to be unable to put up fat, and may die in an emaciated condition without attempting to hibernate.[3] They must find the conditions of life harder than the earlier litters, but Mr Steele Elliott has kept them successfully through the winter.

Hibernation is more rigidly fixed in the routine of life in dormice than in hedgehogs. The influence of temperature[4] is shown, however, by their greater activity when kept warm in confinement, so that cold is evidently a predisposing cause, a stimulus which, as it were, starts the process.[5] It may not be more than this, since the corresponding condition known as "æstivation" manifests itself in the Tenrec[6] of Madagascar under precisely opposite conditions, namely, in the hot season.

The processes concerned are evidently very complicated and incapable of explanation under any single heading. It is

[1] Newly born young, Bridgnorth, Shropshire, second week of October (Pitt, *MS.*); one ready to leave the nest, Skirmett, Buckinghamshire, 25th November, hence born say on the 4th (Cocks, *MS.*).

[2] As in the British Museum *Guide to the British Vertebrates*, 1910, 5.

[3] R. F. Tomes, in Bell, ed. 2, 284. In one case a member of a spring brood became torpid six weeks later than an adult.

[4] Marshall Hall, art. "Hibernation" in Todd's *Cyc. Anat. and Phys.*, 1839, 764-776; see also Pocock, *op. cit.*; and bibliography in *Phil. Trans. Roy. Soc.*, London, 1832. In 1792 a Mr Gough informed William Bingley that two captive dormice became inactive whenever the thermometer dropped to 42° F., resuming their activity at 47° F. Gough's figures are probably too high, since the average minimum, *i.e.* nocturnal, temperature of April, the month of awakening, varies between 37·3° on the 1st and 40·3° on the 30th. The corresponding temperatures occur in the autumn between the 4th (40·3°) and 15th November (37·4°). For these figures, compiled from the records for the sixty-five years 1841 to 1905 at Greenwich, I am indebted to W. W. Bryant, of the Royal Observatory. They must be taken as applying only roughly to other districts, and of course vary considerably from year to year. In 1793 Gough fed another dormouse well from April throughout the succeeding summer and winter, with the result that, although without artificial heat, it remained in good health and high condition, and during that winter never slept for more than forty-eight hours consecutively, and that but seldom; it was also active in the winter of 1794-5.

[5] As Karl Semper puts it (*Animal Life*, 1906, 111), by reduction below the optimum, which optimum may, in different animals, be high or low.

[6] *Centetes ecaudatus.*

quite likely that in many mammals the accumulation of fat,[1] which in temperate and arctic climates is usual in autumn, causes a progressive decrease of metabolic activity, and that the advent of a certain degree of cold, which is no doubt fairly definite for each species, consummates the matter by bringing the vital processes almost to a standstill. Add to this the effect of long custom regulating by inheritance the exact time or conditions under which the machinery shall slow down, and we seem nearer to a satisfactory explanation. But the actual process is in life influenced by questions of food and of individual differences. Thus, while dormice seem to have acquired such similarity of constitution that all the individuals may be said to become "ripe" for hibernation at about the same time, the same process in hedgehogs is spread over a much longer period, and the "ripening" is reached in a much more uncertain manner. The difference is probably connected with the more abundant food and the greater hardiness of hedgehogs; it also indicates a higher degree of specialisation in dormice. Both animals agree in that hibernation, having been once properly started, runs a more or less normal course until the body, having absorbed the fat by which its vital processes have been clogged, is stimulated to fresh activity by the warmth of spring, a warmth coincident with a renewed food-supply.

Bats exhibit two forms of hibernation. Some species, such as Leisler's Bat, are highly specialised and experience a regular and normally continuous torpidity, and probably in these the process has been so ingrained by inherited habit that the stimulus of temperature and fat accumulation are hardly needed. In other species, such as the Pipistrelle, hibernation is intermittent, and here temperature would seem to be the sole stimulus—the temperature at which the food-supply disappears. In this respect the Pipistrelle is less specialised than bats which hibernate more regularly.

Hibernation may, therefore, be of two kinds—continuous, as in the Dormouse; intermittent, as in the Pipistrelle. It does not preserve the animal from cold, since it will die if not sheltered

[1] As suggested for *Glis* by Aug. Forel, who likened hibernation to catalepsy and hypnotic sleep (*Révue de l'hypnotism*, translated in *Zoologist*, 1887, 281); and by W. L. Hahn (see above, Vol. I., 29) for bats. Thin animals certainly cannot hibernate successfully.

by a warm nest[1] or otherwise protected; it is rather a means of slowing the vital processes and utilising over-accumulation of fat during the season when food is harder to obtain. Hence it is caused by questions of food-supply rather than of temperature, although temperature must not be left out of account.

The varying behaviour of a species under different conditions is shown by its habits on mountains, where the altitude determines the nature and date of hibernation. A North American Rock-Squirrel[2] hibernates only at high altitudes, and in the Marmots[3] of the Yakh-su Valley, Bokhara, the annual routine varies as follows:—At a height of 6000 feet they do not appear at the entrance of their subterranean abodes after the middle of August. Two thousand feet higher their feed is green much longer, and there they do not retire before the beginning of September. At 10,000 feet the cold alone sends them to sleep, because the water trickling from the snow keeps little kitchen-gardens growing for them.

Few animals are better suited than the Dormouse for the cages of those who love pets. Although it can on occasions be frightened into biting, as stated above, it rarely resents being handled or loses its temper, and it may become so tame as to recognise its owner and respond to a call.[4] It readily produces young in confinement. Like other small rodents, under the unnatural conditions of captivity it occasionally gnaws away portions of its own[5] or of a comrade's tail, and may even become cannibalistic.[6] The two last tendencies may indicate the absence of something necessary to its comfort, and Monsieur Lataste attributes[7] the death of captives during hibernation to loss of moisture by evaporation in a dry atmosphere.

Both when wild or in captivity this is a particularly silent

[1] After the severe winter of 1860-61 Laver found many dead in their nests in Essex. Yet they survive much severer winters in continental Europe, where they probably hibernate earlier or make their winter-nests more carefully.

[2] *Citellus;* see E. A. Mearns, *Bull. U.S. Nat. Mus.*, 1907, No. 56, 317.

[3] W. R. Rickmers, *Geographical Journal*, 1899, 604-605.

[4] J. A. Willmore, *Zoologist*, 1885, 304. For a good account of a captive dormouse by Hadfield, see *Journ. cit.*, 1862, 8025; 1863, 8481.

[5] Lataste, *op. cit.*, 42-43.

[6] For a female killing and eating a portion of a male confined with her in a roomy cage, see C. A. A. Dighton, *Nature Notes*, 1899, 75.

[7] An observation which, as he points out, applies generally to small vertebrates, as bats, reptiles, and, even more so, to batrachians.

animal. It emits, however, when frightened, a slight hissing,[1] described also as a "querulous cry,"[2] or, when expressing anger, a violent piping sound.[3] A "low whistling" is attributed to it by Mr Richard Kearton,[4] who has heard woodmen call it the "Singing Mouse."

Gough's specimen mentioned above must have survived for about four years in captivity, as also did one kept by Capt. Hadfield.[5] This period exceeds anything in the experience of the authorities of the Zoological Gardens,[6] where seventeen individuals had an average longevity of only three and a half, and a maximum of only thirteen months.

There are not many superstitions connected with this animal, although the older writers of pharmacies held some remarkable views in regard to its efficacy as a constituent in prescriptions. The majority, if not all, of these notions were based upon foreign beliefs applied to foreign species. Topsel, for instance, whose work is usually such a fertile hunting-ground for those in search of quaint information, does not appear to have known the British Dormouse, and Mr Millais quotes the German writer, Dr F. Helm,[7] without, however, noticing that he wrote of the Garden Dormouse of continental Europe.

[The "Button-Mouse" of Orkney, reported to Baikkie and Heddle (15, footnote) as being only 2 ins. long and "frequently found asleep rolled up in the shape of a ball," was thought by Forsyth Major (*Zool. Garten*, May 1905, 129-138), though on slight evidence, to be possibly a "Birkenmaus" of the genus *Sicista* (Gray, 1827, antedating *Sminthus*, Nathusius, 1839). This genus ranges from Central Asia to Denmark and South-eastern Norway, where the species is *S. trizona* of Petényi. It belongs to the family *Zapodidæ*, and is characterised by external murine appearance, but has 4+4 upper cheek-teeth, the crowns with two rows of tubercles arranged longitudinally.]

[1] Lataste, *op. cit.*, 44. [2] Mayne Reid, *op. cit.*, 104. [3] Rabus, *op. cit.*

[4] *The Fairyland of Living Things*, 1907, 83. [5] *Fide* Rope, *op. cit.*, 1885, 213.

[6] See P. Chalmers Mitchell "On Longevity and Relative Viability in Mammals and Birds," in *Proc. Zool. Soc.*, London, June 1911, 447. This Dormouse is not mentioned in Max Schmidt's paper "On the Duration of Life of the Animals in the Zoological Garden at Frankfort-on-the-Main," in *Proc. cit.*, 20th April 1880, 299-319.

[7] *Zool. Garten*, 1887, 217-219, translated in *Zoologist*, 1888, 14-16.

MURIDÆ.

MICE AND RATS.

These are small rodents of varied habits and world-wide **distribution**. They date from the lower Eocene of North America and the lower Oligocene of Europe.

They have the thumbs rudimentary, the clavicles well developed, the tibiæ and fibulæ united. The **skull** has contracted frontal bones without post-orbital processes; slender zygomatic arches in which the short jugal bones are generally reduced to splints between the long zygomatic processes of the maxillæ and squamosals; the lower roots of the former processes more or less flattened into perpendicular plates; and the infra-orbital foramina tall and wide above, narrow below.

The **dental formula** is usually given as:—

$$i\,\frac{1-1}{1-1},\quad c\,\frac{0}{0},\quad pm\,\frac{0}{0},\quad m\,\frac{3-3}{3-3}=16;$$

this covers all, except a few Oriental forms, in which the posterior cheek-teeth disappear; but Forsyth Major (*Atti. Soc. Ital. Sci. Nat.*, xv., 1872, 111) considered that in the *Microtinæ* the anterior cheek-teeth are persistent milk-molars.

The **cheek-teeth** are superficially very diverse in structure. They may be high- or low-crowned, rooted or rootless, with prismatic or tubercular crowns of various degrees of complexity. All, however, may be traced to a common origin, a primitive, short-crowned, rooted organ with a highly complicated tubercular grinding surface. Even in the most highly specialised *Microtinæ* the young unworn cheek-teeth bear for a short time a tubercular enamel cap suggestive of their ancestry; and a tubercular tooth may wear down with use to a prismatic arrangement.

The food varies from grass to flesh, though no species[1] is entirely carnivorous; hence the *Muridæ* are almost ubiquitous, often occur in great numbers, and have probably caused more injury to man than any other mammals. Their destruc-

[1] All British mice and rats are at times cannibals, *Epimys norvegicus* and *Evotomys glareolus* being probably the most guilty.

tive power caused them to attain importance in mythological systems of different parts of the world from the earliest times, as traced by Fraser in *The Golden Bough* (pt. v., vol. ii., 1912). In certain favourable seasons, recurring irregularly or in an unknown cycle, their numbers multiply exceedingly, and thus exert an extraordinary influence on other mammals and birds to which they are an indispensable prey, especially in sub-arctic regions (see Cabot, *In Northern Labrador*, 1912, App., 287-292; Thompson Seton, *The Arctic Prairies*, 1912, 107); in these years of increase they are specially disastrous to agriculture, but "mouse-plagues" are fortunately not frequent in Britain. Sometimes, as in the well-known case of the lemmings, the superfluous population may attempt to "migrate" to new districts, but rarely, if ever, with success. "Mouse-years" are, perhaps, caused by unusual abundance of food, and are characterised by exceptional fertility, in which the predatory creatures temporarily participate. Fertility decreases in the succeeding years of scarcity; frequently also disease appears, until the animals concerned almost vanish temporarily.

Swimming:—Although several British species swim well, they always use all four legs like a dog, none having acquired a more specialised method of propulsion (Adams).

Pairing habits:—As usual in mammals, sexual maturity is attained before full size. In the females the urethra opens separately through a prominent clitoris. The vagina is closed in immature individuals, so that identification of the sexes is difficult in the young, the only guide being the shorter distance from clitoris to anus than from penis to anus. After sexual maturity the open orifice of the vagina makes identification easy. The mature male, if in good condition, is almost always capable of pairing; but in the females, although there is a long polyœstrous sexual season, "heat" lasts for a few hours only, at intervals which, in the absence of impregnation, recur about every eleven days. After effective pairing the vagina is closed, as in bats (see above, vol. i., p. 231), by a vaginal stopper, which remains in position for from twelve to twenty-eight hours, and is then expelled. This is a joint production, but chiefly of the male, which provides the major and central portion, consisting of a spontaneously coagulating

material. The cortical portion supplied by the female is composed of detached epidermical cells. Gestation lasts normally thirteen to twenty-two days; but if the female is already rearing a litter, the development of the embryos may be suspended, their birth being postponed for another ten to fourteen (total, twenty-three to thirty-six) days. Pairing may take place very shortly after parturition. Lactation lasts roughly until the eyes of the young open, that is, about eleven days. The young of all British species are born naked, with a pink skin, blind, and with closed ears, but grow with much rapidity. If disturbed suddenly in the nursery the mother rushes out with her babies attached to her teats, but they soon drop off, and, if allowed to do so, she will carry them home in her mouth, her more usual method of handling them (see Lataste, Marshall, etc.).

Longevity:—Little is known on this point, and the general statement of Metchnikoff (*The Prolongation of Life*, 1907, 57), that the limit is five or six years, is probably not far from the truth. No member of the family has reached seven years in the London Zoological Society's Gardens (Mitchell).

History (including *Muscardinus*):—Accurate knowledge of the distinctions between the various species of rats and mice is of quite recent growth. The older naturalists seem to have confused shrews and mice, and Linnæus's genus *Mus* embraced twenty-two rodents now assigned to almost as many genera. Amongst British authors, Merrett in 1666 mentioned five species, only four of which are rodents: "the house Mouse," "a Rat," "a Water Rat," "the Erdshrew or Field Mouse," and "a Sleeper or Dormouse." Ray (1693) rightly separated the mice from the shrews, which latter he called *Mus araneus*; he added the Field Mouse. Seventy years later Pennant (1st ed., 1766) knew of only two additional species, the Norway Rat and the "Short-tailed Field Mouse." Correct technical names first appear in Berkenhout (1769), who used a single genus *Mus* for the above seven rodents, together with the Harvest Mouse which he added to the list. In Turton (1807) the Dormouse is transferred to the genus *Myoxus*, all the other species remaining in *Mus*, a classification which long prevailed, but in 1828 Fleming adopted the genus *Arvicola* for his Field

and Water "Voles." No further change was made until in 1835 Jenyns, by the addition of the "Bank Campagnol," brought the list up to nine. Fleming's arrangement of genera also continued unaltered through the works of MacGillivray (1837) and Bell (1837 and 1874), until in 1895 Lydekker replaced *Myoxus* by *Muscardinus* and *Arvicola* by *Microtus;* he also admitted the Yellow-necked Mouse, bringing the number of species up to ten. Johnston (1903) adopted the genus *Evotomys* for the "Bank Vole"; he graded the Yellow-necked Mouse as one of five sub-species of his *Mus sylvaticus*, which, if all reckoned, make a total of thirteen. At this period the institution of sub-species and the preliminary difficulties of arranging them caused some instability. Millais (1905), retaining the same genera as Johnston, placed the Water Rat in the sub-genus *Arvicola;* his *Microtus orcadensis* raised the number of species to ten, in addition to which five sub-species of Field Mouse, two of House Mouse, three of Black Rat, with the Skomer and Sanday "Voles," both as sub-species, made a total of nineteen recognisable forms. No more recent work of authority has been published on British mammals, but in Miller's *Catalogue of the Mammals of Western Europe* (1912) there are eight genera, *Muscardinus*, *Evotomys*, *Microtus*, *Arvicola*, *Apodemus* (= *Mus sylvaticus*), *Micromys* (= *Mus minutus*), *Epimys* (= *Mus rattus* and *M. norvegicus*), and *Mus*, the latter now restricted to the House Mouse and its allies. Almost all the old species have now become genera, and, with the various recently discovered insular forms, they now reach nineteen, or, adding sub-species and admitting the Alexandrine Rat, a total of twenty-four recognisable forms. Some of the recent additions to the list are as distinct as any of the older forms, and are of considerable importance as representing survivals from an older fauna, and there can be no doubt about the interest of all of them. The present work in the main follows Miller's arrangement, but more recent study and ampler material has suggested alterations and one or two additions.

Pelage:—The general colour is derived from a mixture of the tips of at least two kinds of hairs. Of these the sparse longer are dusky; they represent the bristles of some foreign species. The abundant shorter hairs form the underfur; they

THE DORMOUSE.

are annulated, the basal and major portions being usually dusky. The first or juvenal coat of the **young** is distinct from that of adults, and precedes a post-juvenal coat of intermediate character. Two moults, one at each change of season, are probably normal, but their regularity is much interrupted by variable weather, the condition of the animals, and the influence of the long breeding season. The system of pigmentation and the principles of coat pattern are probably somewhat similar throughout the family, but having been chiefly studied in the House Mouse, are described under that species.

Droppings:—These are very distinct from the more or less rounded crotties of the *Leporidæ*, being elongated, thicker in the middle and tapering to blunt points at each end. Except in size, they are not distinctive as between the various species.

The British species fall into three **sub-families**:—the locally extinct *Cricetinæ*, or hamster-like rodents; the *Microtinæ*, or voles and lemmings; and the *Murinæ*, or true mice and rats.

A KEY TO BRITISH MURIDÆ,

WITH *MUSCARDINUS.*

I. EXTERNAL CHARACTERS:—

I. Size larger ("rats," with head and body not less than 175, hind foot not less than 30 mm.):—

1. Tail slightly more than half as long as head and body; ear 16 to 18 mm. . . *ARVICOLA.*
   - (A) Upper side brownish . . . *A. amphibius amphibius.*
   - (B) Upper side blackish . . . *A. amphibius reta* (Scotland, chiefly Highlands).
2. Tail about as long as, not longer than, head and body; ear 19 to 21 mm. . . *EPIMYS norvegicus.*
3. Tail longer than head and body; ear 24 to 25 mm.:—
   - (A) Upper side brownish . . . *E. rattus alexandrinus.*
   - (B) Upper side blackish . . . *E. rattus rattus.*

II. Size smaller ("mice," with head and body not exceeding 130, hind foot rarely reaching 27 mm.):—

- 1. Tail bushy, colour brownish-yellow . . . *MUSCARDINUS avellanarius.*
- 2. Tail scaly or sparsely haired, not bushy:—
  - (A) Tail distinctly less than half as long as head and body . . . . *MICROTUS.*
    - (A) Size smaller (head and body averaging 100, hind foot 16-18 mm.), colour brighter (back in extreme cases rufous) *M. hirtus.*
    - (B) Size larger (head and body 110-125, hind foot 18-20 mm.:—
      - (A′) Colour brownish . . . *M. agrestis.*
        - (a) Upper parts with decided tinge of russet . . . *M. a. neglectus* (Scottish Highlands).
        - (b) Upper parts without tinge of russet:—
          - (a′) Under parts washed with wood brown (the hair-bases concealed); coat thick (hairs of back 13 mm.) . *M. a. exsul* (Hebrides).
          - (b′) Under parts dusky (the slaty hair-bases taking part in the general coloration); coat thin (hairs of back 8 mm.) *M. a. macgillivraii* (Islay).
      - (B′) Colour above rich brown, beneath buff . . . . *M. orcadensis* (South Orkney Islands).
      - (c′) Colour above greyish-brown, beneath buffy-grey . . *M. sandayensis.*
        - (a) Colour paler, back light "hair brown" . . . *M. s. sandayensis* (Sanday Island, Orkneys).
        - (b) Colour darker, back dark "hair brown" . . . *M. s. westræ* (Westray Island, Orkneys).
  - (B) Tail about half as long as head and body *EVOTOMYS.*
    - (A) Size smaller (head and body 90-100, hind foot 15·4-17 mm.), colour deeper *E. glareolus britannicus.*
    - (B) Size larger (head and body 100-110, hind foot 18-19 mm.), colour brighter . *E. skomerensis* (Skomer Island).
    - (C) Size as in *skomerensis*, colour as in *glareolus* . . . . *E. alstoni* (Mull).

(C) Tail about as long as head and body:—

(A) Size smaller (maximum of head and body about 75, of hind foot about 16 mm.) . . . . . *MICROMYS minutus.*

(B) Size larger (minimum of head and body about 75, of hind foot (rarely) 16 mm.):—

(A′) Hind foot 16-19 mm. . . *MUS.*

(a) Colour of under side markedly lighter than that of upper side, hind foot broader (4 mm.) . *M. muralis* (St Kilda).

(b) Colour of under side not markedly lighter than that of upper side, hind foot narrower (3-3·5 mm.) . . . . *Mus musculus.*

(B′) Hind foot 20-26·5 mm. . . *APODEMUS.*

(a) Size smaller (head and body about 95, hind foot about 22 mm.) . . . . *A. sylvaticus.*

(b) Size larger (head and body to about 126 mm., hind foot to about 26·5 mm.).

(a′) Under parts white:—

(α) With a collar-like chest-spot . . . *A. flavicollis wintoni.*

(β) Without a collar-like chest-spot . . . *A. fridariensis* (Fair Island).

(b′) Under parts more or less washed with buff or brown:—

(α) Under parts not so heavily washed . . . *A. hebridensis* (Outer Hebrides).

(β) Under parts heavily washed *A. hirtensis* (St Kilda).

II. TEETH AND SKULLS:—

I. Mandibular angle perforate; cheek-teeth 16 . *MUSCARDINUS avellanarius.*

II. Mandibular angle imperforate; cheek-teeth 12:—

1. Skull angular; cheek-teeth with prismatic crowns:—

(A) Palate simple, with shelf-like posterior edge; cheek-teeth rooted . . *EVOTOMYS.*

(A) m^3 with two internal infolds . . *E. glareolus.*

(B) m^3 with three internal infolds:—

(A′) Brain-case smooth and convex . *E. alstoni* (Mull).

(B′) Brain-case flattened . . *E. skomerensis* (Skomer Island).

(B) Palate complicated, with lateral pits; cheek-teeth rootless:—

(A) Size larger; "rats," with condylo-basal length rarely less than 39 mm.; m_1 with three closed triangles . . } *ARVICOLA amphibius*.*

(B) Size smaller; "mice," with condylo-basal length rarely reaching 30 mm.; m_1 with five closed triangles . . } *MICROTUS*.

(A′) m^2 with four dentine-spaces:—

(a) m_1 with anterior loop nearly bilaterally indented:—

(a′) Cranium depressed . . } *M. sandayensis westræ* (Westray Island, Orkneys).

(b′) Cranium not depressed . } *M. orcadensis* (South Orkney Islands).

(b) m_1 with outer infold of anterior loop much less developed than inner infold . . . } *M. sandayensis sandayensis* (Sanday Island, Orkneys).

(B′) m^2 with a small 3rd inner salient angle, making five dentine-spaces:—

(a) m^1 with three inner salient angles; bullæ small:—

(a′) Size smaller (condylo-basal length not exceeding 26 mm.) . } *M. hirtus*.

(b′) Size larger (condylo-basal length reaching 28-29 mm.) . } *M. a. neglectus* (Scottish Highlands).

(b) m^1 frequently with a small 4th inner salient angle; bullæ large:—

(a′) Temporal ridges anteriorly parallel in adults . . } *M. a. macgillivraii* (Islay).

(b′) Temporal ridges anteriorly converging in adults . . } *M. a. exsul* (Hebrides).

2. Skull rounded; cheek-teeth with tubercular crowns:—

(A) Rostrum short (distance from orbital constriction to anterior edge of nasals about $\frac{1}{3}$ total length of skull) . . . } *MICROMYS minutus*.

(B) Rostrum normal (distance from orbital constriction to anterior edge of nasals about $\frac{1}{2}$ total length of skull):—

(A) Upper incisors notched; m^1 much longer than m^2 and m^3 together . } *MUS*.

(A′) Mesopterygoid fossa sharply pointed anteriorly . . } *M. muralis* (St Kilda).

(B′) Mesopterygoid fossa squarely truncate anteriorly . . . } *M. musculus*.

* The sub-species of *Arvicola amphibius* are omitted, as they do not possess diagnostic cranial or dental characters.

(B) Upper incisors not notched; m^1 about equal in length to m^2 and m^3 together:—

(A′) Size smaller; "mice" with condylo-basal length rarely exceeding 28 mm. . . . . } *APODEMUS.*

(a) Skull comparatively massive and angular . . . } *A. flavicollis.*

(b) Skull comparatively light and smooth:—

(a′) Size smaller (condylo-basal length not exceeding 24 mm.) } *A. sylvaticus.*

(b′) Size larger (condylo-basal length not less than 24 mm.):—

(α) Skull slender; coronoid process of mandible reduced . . . } *A. fridariensis* (Fair Island).

(β) Skull normal; coronoid process of mandible not reduced:—

(α') Size smaller (condylo-basal length 24-25 mm.) } *A. hebridensis* (Outer Hebrides).

(β') Size larger (condylo-basal length 25·5-27 mm.) . } *A. hirtensis* (St Kilda).

(B′) Size larger; "rats" with condylo-basal length rarely less than 38 mm. . . . . } *EPIMYS.*

(a) Size smaller (condylo-basal length rarely reaching 45 mm.); cranium broader (external length of a parietal distinctly less than breadth of cranium between lateral ridges); m^1 without anterior cingulum, with distinct outer tubercle to first lamina . . . } *E. rattus.**

(b) Size larger (condylo-basal length rarely less than 45 mm.); cranium narrower (external length of a parietal about equal to breadth of cranium between lateral ridges); m^1 with anterior cingulum, without outer tubercle to first lamina . } *E. norvegicus.*

* The sub-species of *Epimys rattus* are omitted, as they do not possess diagnostic cranial or dental characters.

[Sub-family *Cricetinæ*.[1]

HAMSTERS[2] AND WHITE-FOOTED MICE.

This large sub-family is specially characteristic of both Americas, where it almost certainly originated, but occurs also from Eastern China to Central Europe and in South Africa.

It is first known from the lower Eocene of North America (*Eumys*, Leidy, 1857). In the lower Oligocene (Quercy) of Europe it is represented by four species of *Cricetodon* (Schlosser, *Palæontographica*, xxxi., 1884, 96-97), some of which survived in Germany and France until the middle Miocene (see

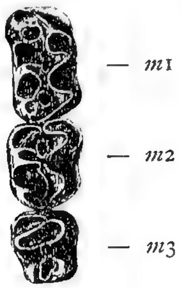


FIG. 52.—RIGHT UPPER CHEEK-TEETH OF *Cricetus runtonensis*, from the Pliocene of West Runton, Norfolk (crown view, magnified). From *Geol. Mag.*, March 1909, III, by kind permission of Dr Henry Woodward and E. T. Newton.

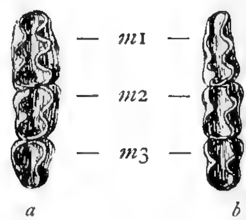


FIG. 53.—CHEEK-TEETH OF *Phodopus sanfordi*, from the Pleistocene of Hutton Cave, Somersetshire; *a*, left upper; *b*, right lower (crown view; six times life size; after Sanford).

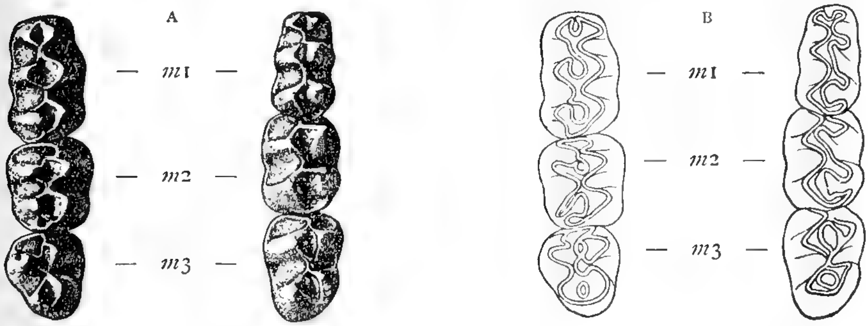
Forsyth Major, *Geol. Mag.*, August 1899, 372), but have not been identified from Britain. *Cricetus* (Leske, 1779) itself is found first in the middle Pliocene of Europe. One species, *C. runtonensis* (Newton, *Geol. Mag.*, March 1909, 110-12) occurs in the late English Pliocene of the West Runton Upper Freshwater Bed; it was slightly larger than the recent *C. cricetus*, and presents some dental peculiarities. Another,[3] of mouse-like size, from the Pleistocene of Hutton, Mendip Caves, Somerset, was referred by Sanford (*Quart.*

[1] Extinct in Britain. [2] A German word of uncertain origin.

[3] Perhaps near Pomel's *C. musculus*, described (*Catalogue Méthodique*, 32, 1853) from Brèche de Coudes, Allier, Central France.

Journ. Geol. Soc., xxvi., 1870, 128, pl. viii., fig. 6; and *Proc. Somerset. Arch. and Nat. Hist. Soc.*, xv., 1868-69, 56, fig. 6, 1870) to *Mus songarus*, a form described by Pallas (*Reise*, 1773, ii., 703, pl. B., 1) from the river Irtisch, Siberia, but now placed in the genus *Phodopus* (Miller, *Smiths. Misc. Coll.*, 12th Jan. 1910, 498; Hollister, *Journ. cit.*, 29th Nov. 1912, 3). The Somerset specimens cannot, however, be synonymised with *P. sungorus*, and need a new name. They may be appropriately known as *Phodopus sanfordi*, and thus form an interesting addition to the British fauna. *Phodopus*, which is in external form and teeth less highly modified than *Cricetus*, is known also from the Altai District (*P. crepidatus* of Hollister), and North-eastern Mongolia (*P. campbelli* of Thomas).

The *Cricetinæ* are, like the pikas, of peculiar interest, being ancient generalised forms which have retained primitive



(1) (1*a*) (2) (2*a*)

FIG. 54.—CHEEK-TEETH OF *Cricetus cricetus* (crown view; five times life size); A, unworn; B, slightly worn; 1, 1*a*, right upper; 2, 2*a*, left lower. From Miller's *Catalogue of the Mammals of Western Europe.* (By kind permission of the Trustees of the British Museum of Natural History.

characters, suggestive of the probable development of the more highly specialised *Microtinæ* and *Murinæ* from a cricetine-like ancestor. Their cheek-teeth are rooted, and, as in the *Murinæ*, the crowns are tubercled, but the arrangement in the upper jaw is one of two, not three, rows. As the tubercles wear down, a triangular, microtine-like pattern is revealed.

The Cricetines, like many other groups represented in extra-arctic regions of both hemispheres, have no widespread form identical or representative in both. They are older than the existing land connections, and their present absence

from Britain, the Ultima Thule of their wanderings, must be regarded as due solely to local causes, perhaps connected with the latest Glacial Period, or to the competition in large numbers of the more highly organised *Muridæ*. Having been exterminated in Western Europe, they were unable to return to Britain in time to reoccupy it. The absence of the Hamster, *Cricetus cricetus* (Linnæus),[1] from Skandinavia, Denmark, Britain, the Iberian Peninsula and Italy, marks the present stock as being recent immigrants to the rest of Europe; the immigration is perhaps still in progress, the species having much extended its range in France since 1870 (see *A travers le monde*, v., 41, 14th October 1899, 325-326).]

Sub-family *Microtinæ*.[2]

VOLES AND LEMMINGS.[3]

The **classification** of this sub-family is largely due to Miller, and is a natural system in contradiction to the artificial arrangements of most previous investigators—de Sélys, Blasius, Fatio, Baird, Coues, Blanford, and Lataste; for references to the works of whom, and for further technical details, see Miller's "Genera of Voles and Lemmings," being *North Amer. Fauna*, No. 12, 1898; also Hinton's "Preliminary Account of the British Fossil Voles and Lemmings," in *Proc. Geol. Assoc.*, 3rd June 1910, 489-507.

Characters:—These rodents are all burrowers, more or less completely adapted to an earthbound or even a subterranean existence, and therefore lacking the variety of shape and habits which is so prominent a feature of the *Cricetinæ* and *Murinæ*. Their eyes are usually small, and their external ears reduced in size.

In the **skeleton** the pubic symphysis is greatly shortened. In accordance with the diet of coarse and tough vegetable

[1] The report of its naturalisation in South Ronaldshay, Orkneys, "having been brought there in a Norway vessel, which suffered shipwreck," was shown by John Wolley (*Zoologist*, 1849, 2344) to be an error, perhaps based on the known presence of *Epimys rattus*.

[2] *Arvicolinæ* of many older writers.

[3] "Lemming," from the Swedish and Norwegian, probably = "destroying."

substances, the cheek-teeth and masticatory muscles are exceptionally powerful; the **skull** is massively constructed, and several of its paired bones, such as the maxillæ, palatines, and frontals, which usually remain free in other *Muridæ*, are fused together at an early stage in the existence of the individual (see Winge, *Vidensk. Med. Nat. For. Kjob.*, 1881, 37-50 (1882); *Grönlands Pattedyr*, 1902, 358; *Danmark's Pattedyr*, 51, 68-79).

The **cheek-teeth** are hypsodont and often endowed with the power of persistent growth. Their evolution, which is analogous to that of the pikas (see above, pp. 155-158), has been worked out by Hinton, to whom I am indebted for a *résumé* of his, at present unpublished, results. Although the actual ancestors of the *Microtinæ* have not yet been discovered, there can be no doubt that their cheek-teeth were of a brachyodont, tubercular type; the apical or first-formed and most conservative parts of these teeth in recent forms still retain such a structure, and in the more primitive genera, such as *Dicrostonyx*, remains of three longitudinal rows of tubercles are present in both upper and lower series when unworn, showing that the group has descended from a stock with murine rather than cricetine cheek-teeth. Such brachyodont teeth were adapted for crushing and grinding; they have gradually been converted into a most perfect apparatus for slicing and shearing. The first step in the process has been the atrophy, by fusion or blending, of some of the less useful primitive tubercles. The cusps have thus been arranged in an inner and outer alternating series of triangular form, the evolution of which can be readily appreciated by examining the changes in pattern shown by the molars of *Cricetinæ* in different stages of wear (Figs. 52 and 54).

The transition from a soft and succulent to a tough and dry diet has been gradual. It has been accompanied by steadily increasing wear of the crowns of the cheek-teeth, by increased nutrition of these organs, and by prolongation of their period of growth. Since during the earlier stages growth exceeds attrition, the cheek-teeth have become hypsodont; in later stages growth and wear are equal, and this condition persists until death in the higher genera of the group, as in *Microtus*; in lower forms, as *Evotomys*, a time comes when the enamel organs fail, and thereafter growth of the crowns ceases, the

dentinal pulps gradually atrophy, and in so doing form two tapering roots—an anterior and a posterior—to each tooth.

During their progress towards hypsodonty and persistent growth the inner and outer triangular cusps have been converted into triangular prisms, the structure of which partially explains the final steps in evolution of the cheek-teeth of the higher *Microtinæ*. Each triangle is bounded before and behind by enamel (Fig. 57, *e*); with a thick internal lining of hard and dense dentine (*d*) and a central core of a softer, more highly vascular tissue, the osteo-dentine (*o*). Owing to its superior powers of resistance the enamel always stands out in relief upon the triturating surface of the teeth. In lower forms, as *Evotomys* (Fig. 63), the enamel is rather thick, and, as in primitive mammals generally, of uniform thickness at practically all points upon the margins of the teeth. In the higher forms, *i.e.* those like *Microtus* in which the power of subsisting upon a coarse and tough vegetable aliment reaches its highest expression, the cutting and slicing functions of the cheek-teeth are most completely developed, and in order to put them in operation the motion of the jaw becomes almost exclusively an antero-posterior one. In consequence of this, certain portions of the enamel become of diminished utility and tend to become thin; other portions, directly obstructing the antero-posterior motion of the jaw, atrophy and disappear. In most living *Microtinæ*, therefore, the enamel has become differentiated into thin and thick portions; the thick is usually found on the concave sides of the prisms, which are, in upper teeth, the posterior, in lower, the anterior; the thin enamel forms the convex sides; further, in the anterior or posterior "loops" of m_1 and m^3, and at the tips of the salient angles, the enamel is frequently lacking. As in other primitive mammals, the valleys or infolds were originally devoid of cement, and this condition is still met with in some genera which in many other ways seem to stand as high or higher than the majority of their allies, *e.g.*, in *Dicrostonyx* (Fig. 55) and *Ellobius*; in other genera cement is found partially or wholly filling the re-entrant folds or cement-spaces (Figs. 57, 63, etc.).

The reduction in the number of primitive elements characteristic of the ancestral cheek-teeth has not been limited to

obliteration of one of the three longitudinal rows of tubercles, but, in addition, as insisted by Hinton, certain tubercles in the anterior and posterior portions of each tooth have undergone reduction, though to a very variable extent in the different genera. This phenomenon is the expression of a general law, subject in *Microtinæ*, so far as is known, to no exception; thus, even the cheek-teeth of *Dicrostonyx* and *Fiber*, the most complex known in the group, show, when unworn, ephemeral traces of further longitudinal complications which may have been inherited from a remote ancestor.

From a systematic point of view the enamel pattern of the cheek-teeth of *Microtinæ* is of great importance. Although abnormalities are found in 25 per cent. of individuals of some species, these are frequently appearances caused by different stages of wear. The pattern is, on the whole, remarkably characteristic and constant in each species or group of species, certain teeth, especially m^3 and m_1, being particularly diagnostic. The arrangement in the various species will be more easily understood by a reference to the teeth of *Dicrostonyx*, in which the pattern is seen in its longitudinally most complex and primitive form—a form from which all the other patterns may be derived by the reduction or fusion of one or more elements. For convenience sake the parts of each upper tooth are enumerated from before backwards, those of each lower tooth from behind forwards. The prisms are spoken of as "triangles" or "loops" according to their form in the crown view of the teeth. In every case where suitable material could be examined, Hinton finds that "loops" are combinations of two or more cusps.

In *Dicrostonyx* (Fig. 55) m^1 is composed of an anterior transverse loop, followed by six alternating triangles, the anterior internal; the postero-internal is somewhat reduced in size, the postero-external is vestigial; briefly described, this tooth has seven dentinal spaces, and presents on each side four salient angles separated from each other by three infolds. m^2 possesses a similar pattern, but is more reduced, having only two instead of three inner triangles following the anterior loop; the anterior is outer instead of inner, and as a whole, this tooth possesses six dentinal spaces, four outer salient angles with

three infolds, and three inner salient angles with two infolds. In some species of *Dicrostonyx* (*D. torquatus* and the extinct British *D. gulielmi*) m^1 and m^2 have, in addition to the parts enumerated above, a minute vestigial postero-internal salient angle (Fig. 55, n^1)—the last trace of what may once have been an important element in each tooth. m^3 is essentially like m^2 in form, differing merely in the degree of reduction of its posterior portion; the first five dentinal spaces are like those of m^2; the fourth outer angle—the vestigial one in the anterior teeth—is here largely developed, as is also, on the inner side, the homologue of the minute postero-internal angles of m^1 and m^2 of *D. torquatus* and *gulielmi*; these two triangles are incompletely separated from each other by the third inner fold, and together they form a crescentic posterior loop; briefly, this tooth has six or seven dentinal spaces, with four salient angles and three infolds on each side.

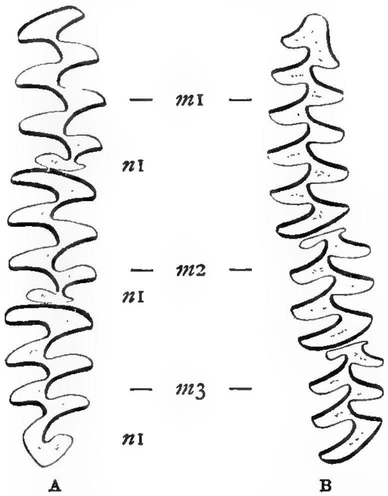


FIG. 55.—CROWN VIEW OF RIGHT UPPER (A) AND LOWER (B) CHEEK-TEETH OF *Dicrostonyx torquatus*. Drawn by M. A. C. Hinton ($7\frac{1}{2}$ times life size).

The lower cheek-teeth of *Dicrostonyx* (as also of other *Microtinæ*) are in general like those of the upper jaw, but the transverse loop is at the posterior instead of at the anterior end of each tooth (Fig. 55, B). m_1 consists of a posterior transverse loop, preceded by seven substantially closed triangles, of which four, including the anterior, are internal and three external; anterior of all is a loop of complex structure, into the composition of which some four or more originally distinct cusps enter; occasionally one or two of the posterior of these may be completely separated off from the more forward part of the loop by infolds in the usual manner, thus increasing the number of closed triangles to eight or nine; there are never fewer than nine dentinal spaces, five outer and six inner salient angles, and four outer and five inner infolds. The two posterior teeth, essentially like each other in form, are

considerably simpler than m_1; each has a posterior transverse loop, preceded by four alternating triangles, exactly corresponding to the hinder part of m_1; in m_2, in front of the fourth triangle, and but partially shut off from it, is a vestigial pair of prisms of which the outer member is the more reduced; in m_3 the reduction of this vestigial pair is carried still further, and the fourth triangle itself is quite small. Each tooth has thus five dentinal spaces, three salient angles and two infolds on each side, and in addition is complicated by the presence of the vestigial structures described.

Dental formula:—Forsyth Major long ago argued that the dental formula of the cheek-teeth should be written as $dm\frac{1}{1}$, $m\frac{1-2}{1-2}$, the anterior cheek-teeth being regarded as persistent milk molars. This view has recently been revived by Hinton; it is based upon the extraordinary complexity of the anterior cheek-teeth and upon various theoretical considerations, and support is lent to it by an instance recorded by Winge of the occurrence of a small fourth posterior cheek-tooth in *M. agrestis*. In describing the teeth here the older notation is retained as being more convenient.

The sub-family is **circumpolar**. Reaching its main development in temperate climates, it ranges south to the northern coasts of the Mediterranean, northern India and Mexico, and north to the limits of mammalian life. It first appears in the Pliocene of Europe, but in America not before the Pleistocene, so it may have **originated** in the Old World.

It is closely related to the *Cricetinæ* and the American Wood Rats (*Neotominæ*), but is readily distinguished by its skull and teeth. Besides the *Ellobii*, which are unknown in our area, it includes two supergeneric groups, the *Lemmi* or lemmings, and the *Microti* or voles, the former extinct in Britain. It possesses great interest from the primitive characters by which it seems to be connected with the Malagasy *Brachytarsomys*, a genus which, so far as structure goes, might itself have been a forerunner of the *Microtinæ* (see Forsyth Major, *Proc. Zool. Soc.*, London, 1st June 1897, 719).

[GROUP LEMMI.

Lemmings are short-tailed microtines. Their external appearance as typified by *Lemmus* is described below. The **skull** is broad and massive; the lower incisors are short, their roots ending on the inner sides of the cheek-teeth, the crowns of which in the upper jaw are of about the same width from front to back.

The lemmings are a highly specialised modern group of a relatively low and decadent type, formerly of wider distribution, but now in course of replacement by more dominant genera. They reached their zenith in the late Pleistocene, the mammalian fauna of which indicates a climate supporting a plentiful vegetation. The bulk of this fauna is now extinct or the members widely dispersed, some to arctic regions, others to mountains, others to islands of mild climate —a combination showing that retreat from competition with the present entirely distinct fauna is the key to their present distribution. Far from being confined by choice to a polar environment, it is probable that the latest glacial period was injurious to the lemmings to the extent of partial extermination, and they would not now be restricted to polar regions did their foes permit them to exist elsewhere. They certainly, in their well-known "migrations," make many attempts to colonise new districts, and these are believed to be invariably failures, owing to the ease with which, in the absence of snow, they are captured by carnivorous enemies. They survive in apparently undesirable regions, because, like the varying hares, they have the power of thriving on coarse, innutritious food, and because, thanks to their small size, they are enabled to shelter themselves under the snow, and thus not only to escape being eaten, but to remain active throughout the winter.

NOTE.—The arguments for lemmings being essentially "arctic" animals have been given by Nehring in his *Tundren und Steppen* (1890, i., 60), and by Stejneger (*Amer. Nat.*, 1901, 101), relying on Merriam's "law" of the distribution of animals and plants in definite climatic life-zones (*National Geog. Mag.*, 29th December 1894, 229-238). The dependence of mammals, except in very special cases, primarily on food rather than on climate has been emphasised by me in the "Mammalia of the Clare Island Survey" (*Proc. R. Irish Acad.*, September 1912, No. 17, 9). All

northern naturalists, *e.g.* Manniche for Greenland, agree about the helplessness of lemmings in the absence of moderately deep snow. In Novaya Zemlya their snow-tunnels are very remarkable, as described by Nordenskiöld (*Voyage Vega*, 1881, i., 146-7); in Alaska, in the absence of snow, their runs may be in moss, and they may have young in every month of the year (Buxton in Allen, *Bull. Amer. Mus. Nat. Hist.*, 31st March 1903, 152). For the ease with which lemmings may be dug out and killed by man or carnivora, see Buxton (*op. cit.*); Preble, *North Amer. Fauna*, No. 22, 1902, 56; and Goldwaite (in Bangs), *Proc. Biol. Soc.*, Washington, 17th September 1897, 237).]

[GENUS LEMMUS.[1]

The true lemmings are stout, short-legged, thickly furred animals, with disproportionately large heads, short but well-developed valveless external ears, and rudimentary tails. Both hands and feet are highly specialised for a fossorial existence, the palms and soles being large, broad, strong, and densely furred, and the pads absent or rudimentary; the digits, except the thumbs, are provided with long, sharp, but simple claws, not subject to periodic changes, and borne on greatly enlarged, unequal phalanges; the thumbs carry remarkably powerful nails.

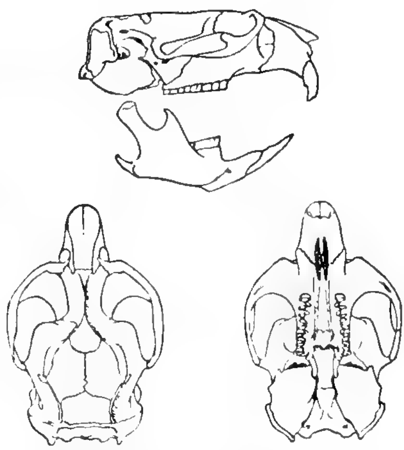


FIG. 56.—SKULL OF *Lemmus lemmus* (life size). From Miller's *Catalogue of the Mammals of Western Europe*. (By kind permission of the Trustees of the British Museum.)

The **skull** is particularly heavy and massive, with low, broad brain-case. The temporal ridges unite to form a knife-like ridge between the orbits. The short rostrum is thick and heavy. The auditory bullæ are large, and of spongy texture. The powerful zygomatic arches are expanded centrally into wide, strongly oblique plates; the anterior edges of the squamosals form narrow but distinct shelf-like post-orbital processes. The pterygoids are short, with the lateral pits of the bony palate deep, and the

[1] Extinct in Britain. *Lemmus*, Link, 1795, antedating *Myodes*, Pallas, 1811, is based on *Mus lemmus* of Linnæus.

anterior edge of the inter-pterygoid fossa carried forward dorsally past the overhanging edge of the palate.

In the **teeth** the ungrooved upper incisors are comparatively slender. The cheek-teeth (Fig. 57) are rootless; their tooth-rows converge anteriorly, their crowns are very broad, and the enamel-pattern is characterised by reduction of dentine-spaces, sharp enamel-angles, and deeply cut infolds; the latter run almost right across *m*1 and *m*2 on the outer upper and inner lower sides; in some cases they are opposed by salient angles presenting a peculiar appearance of square truncation.

Except where modified by the features just described, m^1 and m^2 do not differ from those of normal *Microtinæ*. m^3 is formed of four transverse loops; the first is isolated from the second by a deep outer fold; the second from the third by the approximation of an inner and outer fold, the former a little deeper; the third similarly from the fourth, but the inner fold is very deep, the outer a mere vestige.

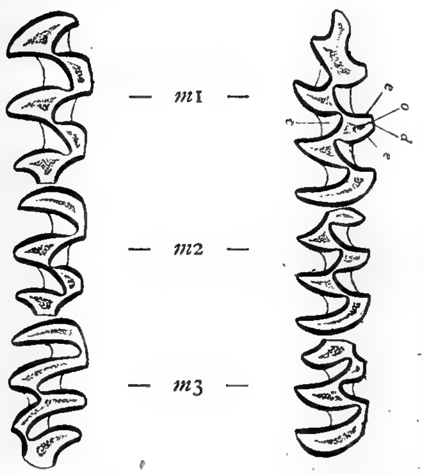
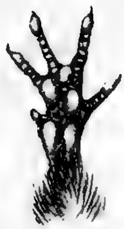


FIG. 57.—CROWN VIEWS OF RIGHT UPPER (A) AND LOWER (B) CHEEK-TEETH OF *Lemmus lemmus* (7½ times life size); from the late Pleistocene of England. (Drawn by M. A. C. Hinton.)

m_1 has the posterior loop preceded by three closed triangles, and an anterior loop formed by the blending of two or three reduced dentinal spaces; it presents three outer and four inner salient angles. m_2 agrees in structure with that of *Microtus*, and differs merely in having the two outer closed triangles relatively small. m_3 is essentially similar; its postero-internal fold is, however, deepened, so that it extends practically across the crown, and the antero-external triangle of m_2 is not represented; there is a large foramen below and behind the alveolus.

The above characters show extreme specialisation in skull and teeth, but in external characters *Lemmus* is not so specialised as *Dicrostonyx*.



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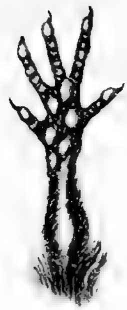

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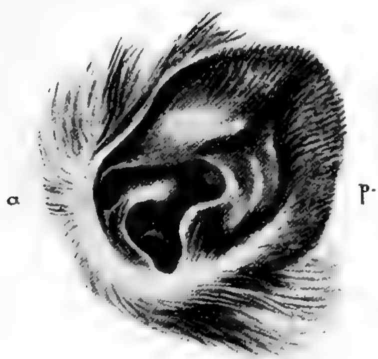

(3)

THE BANK MOUSE—*Evotomys glareolus.*

(1) LEFT HAND AND (2) LEFT FOOT (twice life size);
(3) LEFT EAR ($3\frac{1}{2}$ times life size).

Lemmus is now confined to circumpolar regions, mostly in arctic latitudes, including Novaya Zemlya (*L. obensis*), but not Spitzbergen, Franz Joseph Land, Iceland, or Greenland. In North America it ranges from Alaska to Hudson's Bay, north to about 70° N. lat. in Boothia Felix (Ross), and south to about 55° N. in the Peace River region (Preble); with an insular species, *L. nigripes* (True), in St George's Island, Bering Sea. *L. obensis* (Brants), of Arctic Siberia, has an isolated colony in the Syansk Mountains, west of Lake Baikal, at 2200 feet (Thomas).

L. lemmus (Linnæus),[1] the well-known Norwegian Lemming, extinct in Britain, is now confined to Skandinavia, south to Christiansand (Collett) and northern Wermland (Lilljeborg), with Finland and Russian Lapland to the Kola Peninsula.

It was widely distributed in the **Pleistocene** or post-Pleistocene of Western and Central Europe, its bones having been found in North Germany, Saxony, Poland, Hungary, Belgium, and Switzerland (Hensel, *Zeits. d. Deutsch. Geol. Gesellsch.*, Berlin, vii., 486, pl. xxv., figs. 10, 11, and 15, 1855; Nehring, *Zeits. f. Ges. Naturw.*, Berlin, xlv., 1-28, 1875). Gadow's discovery of "mummies" of a *Lemmus* (Barrett-Hamilton, *Proc. Zool. Soc.*, London, 3rd March 1896, 304), in caves near Athouguia, Santarem, Portugal, has been a stumbling-block to many, who refuse to accept the locality as correct (*e.g.*, Harlé, *Bull. Soc. Géol. de France*, 1909, 98; *Comm. da Commis. do Serv. Geol. de Portugal*, viii., 52, 81, 1910-1911). But Nehring (*Sitzungsb. der Gesellsch. naturf. Freunde*, 1899, 3, 55; also Wiegemann's *Archiv für Naturg.*, lxv. (i.), Bd. 2, 175-182) assigned them to a distinct variety named *crassidens*, on account of its large teeth, and Miller agrees that the Portuguese remains cannot at present be synonymised with *L. lemmus*. This fact supports the unexpected locality, but a collector sent by Hailé to examine all the caves in the neighbourhood failed to find further specimens.

In Great Britain it was first reported by Sanford (*op. cit. supra*, pp. 382-3) from Somerset caves, and it is now known to have been an abundant member of the late Pleistocene, and perhaps

[1] *Mus lemmus*, Linnæus, *Systema Naturæ*, x., 59, described from the mountains of Lappmark, Sweden.

of the prehistoric fauna, having been identified also from Forest of Dean, Gloucestershire; Ightham, Kent; Langwith, Derbyshire; and Dog Holes, Warton Crag, Lancashire. It was probably present at Hoe Grange Quarry, Longcliffe, Derbyshire, as well as (with *Dicrostonyx*) in the earlier brick-earth of Erith, in the Thames Valley (see Newton, *Geol. Mag.*, October 1890, 455).[1]

In Ireland it is known only from Doneraile Cave, Co. Cork, where it was discovered by Ussher in 1904 (*Journ. Cork Hist. and Arch. Soc.*, xvii., 92, 123; *Irish Naturalist*, 1904, 237 and 248, also 1910, 42), along with mammoth, bear, reindeer, wolf, and a large hare (true *Lepus*).

Some of its remains have such a fresh appearance that the animal may well have survived until prehistoric or historic times. Those from Portugal included the entire dried skins and ligaments of two complete individuals.

Hinton concludes that the lemmings, helped by their well-known migratory habits, reached Ireland, with the ancestor of the Irish Hare, during the latter part of the pleistocene period, at which time the land stood high enough to lay bare the bed of the North Sea to a latitude somewhere north of the Dogger Bank. The meagre Irish fauna shows that the connection between Ireland and England could only have been inconsiderable or temporary, probably between Carnarvonshire and Wicklow.

The absence of *L. lemmus* from Siberia, from the south-west and south of Sweden, and from the late glacial deposits of Denmark (Winge, *Vidensk. Meddel. Naturh. For.*, *Kjobenhavn*, 1904, 3, 223) caused Stejneger to suggest (*Smiths. Misc. Coll.*, 4th May 1907, 478), with much probability that, with the Varying Hare of Norway, it reached Skandinavia from Scotland by means of a land bridge across the North Sea.

No ancestral forms of *Lemmus* occur in Britain, whither it probably came from the East. Its absence from eastern North America and Greenland seems to indicate an Old World origin,

[1] Hinton (*Proc. Geol. Ass.*, 3rd June 1910, 496) believes that remains from Uphill Cave, Weston-super-Mare, Somersetshire, represent a second species as yet undescribed.

and that its passage between the Old and New Worlds was by way of Bering Strait.

The principal original references to the ossiferous caves or fissures mentioned in the articles on lemmings are as follows :—

Ightham Fissures, Valley of the Shode, Kent, Abbott and Newton, *Quart. Journ. Geol. Soc.*, 1st May 1894, 171-209; Newton, *Journ. cit.*, August 1899, 419-429. Wye Valley Cave, Forest of Dean, Gloucestershire, Bate, *Geol. Mag.*, March 1901, 101-106. Hoe Grange Quarry, Longcliffe, near Brassington, Derbyshire, Arnold-Bembrose and Newton, *Quart. Journ. Geol. Soc.*, 28th Feb. 1905, 43-64. Langwith Cave, Derbyshire, Mullins and others, *Journ. Derby Arch. and Nat. Hist. Soc.*, 1913. Dog Holes, Warton Crag, Lancashire, Jackson, *Lancashire Nat.*, Nov. 1909, 227-229; Feb. 1910, 323; March 1912, 420-422. Kesh caves, Co. Sligo, Ireland, Scharff, Coffey, Cole, Ussher and Praeger, *Trans. R. Irish. Acad.*, Sept. 1903, xxxii., B. iv., 171-214. See also Blackmore and Alston, *On Fossil Arvicolidæ*, *Proc. Zool. Soc.*, London, 16th June 1874, 460-471.]

[GENUS DICROSTONYX.[1]

The Banded or Arctic Lemmings are less specialised in dentition and skull than the true lemmings, but much more so in external characters, thus enabling them to exist in higher latitudes. Some, at least, of the species whiten in winter. The external ears are quite rudimentary. The hands undergo remarkable seasonal changes. The thumbs are very small, and their nails minute; the claws of the two middle digits in summer resemble those of *Lemmus*, but in winter they are greatly enlarged in conformity with the subterranean life of the animal at that season; after attaining a maximum, portions of them are shed somewhat like the horns of some ungulates; the claws of the second and fifth digits are large, but not peculiar in form. The hind feet, which carry several minute pads near the bases of the claws, are very broad, the proportions of length to breadth being about as two to one.

The **skull** resembles that of *Lemmus*, but is smaller and more lightly built, with zygomata less broadly bent and expanded, lighter and more slender rostrum, and pterygoids proportionately longer. The temporal ridges never unite, and there is consequently a noticeable longitudinal furrow in the

[1] Extinct in Britain. *Dicrostonyx*, Gloger, 1841, based probably on *Mus hudsonius* of Pallas, from Labrador, antedates *Cuniculus*, Coues, 1877, which latter is also preoccupied (see above, p. 172.)

inter-orbital region. The auditory bullæ are not enlarged or particularly spongy. The anterior edges of the squamosals give off very characteristic, peg-shaped, post-orbital processes.

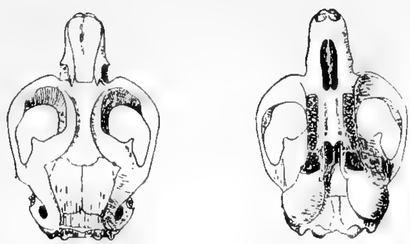

FIG. 58.—SKULL OF *Dicrostonyx* (life size). Drawn by M. A. C. Hinton.

The characteristic pattern of the **cheek-teeth** has been described on p. 388 (Fig. 55). The infolds on the opposite sides being about of equal depth, the dentine-spaces are of nearly equal size on each side. The tooth-rows are nearly parallel, and there is no noticeable foramen behind the alveolus of m_3.

Dicrostonyx is now confined to circumpolar regions, where *D. torquatus*[1] ranges from the eastern shores of the White Sea probably throughout arctic Siberia, and *D. hudsonius* (Pallas),[2] or other species, are found throughout the arctic regions of America and north through the islands of the Polar Sea, where they are sometimes innumerable, through Grinnell and Grant Lands to beyond 83° N. lat. on the north-west coast (Aldrich). In Greenland, *D. grœnlandicus* (Traill, Scoresby's *Journal Voyage Northern Whale Fishery*, 1823, 417) is found from the extreme northern point in about 83° N. along the entire coast, south-west to about 81° N. in Hall's Land, and south-east to 69° N. (Feilden MS.). Feilden (*Quart. Journ. Geol. Soc.*, 1878, 566) found its remains in post-pliocene beds of Grinnell Land, at an elevation of at least 300 feet above present sea-level, and hence argues that it is not a recent immigrant to Greenland. A southern species, *D. unalescensis* of Merriam, occurs at Unalaskah, in about 54° N. lat.

The genus is known as a fossil from France (Puy de Dôme, and Brèche de Coudes, Allier; described by Pomel as *Arvicola* [*Myolemmus*] *ambiguus*, *Ann. Sci. de l'Auvergne*, xxv., 1852, 363; first correctly identified by Hensel in 1855, later by Forsyth Major, *Atti. Soc. Ital. Sci. Nat.*, xv., 1872, 111, pl. 2);

[1] *Mus torquatus*, Pallas, *Novæ Species Quad e Glirium*, 1779, ii., 205, described from the arctic regions of the river Obi, Siberia.

[2] *Op. cit.*, 1779, ii., 208, described from Labrador.

from Quedlinburg, Saxony (Hensel, *op. cit. supra*, p. 393); Eppelsheim, near Darmstadt, Hesse, Germany; and Hohlenstein, near Ulm, South Germany (Forsyth Major).

In England the genus makes its first appearance, with *Lemmus*, in the brick-earth of Erith, Thames Valley (Newton, *Geol. Mag.*, October 1890, 454), and is present also in later pleistocene deposits. It was extremely abundant, and occurred, as first pointed out by Forsyth Major (*op. cit.*, 123), as two cotemporary species now both extinct, *D. gulielmi* and *D. henseli.*

Of these, *D. gulielmi*[1] was described from specimens in the Taunton Museum, obtained in Wookey Hole Cave, Somerset. It is characterised by large size, short and broad incisive foramina, broad nasals, and heavy teeth, m^1 and m^2 having minute postero-internal salient angles. Hinton has identified it from Langwith Cave, Derbyshire (*Ann. and Mag. Nat. Hist.*, July 1910, 38; Forest of Dean Cave, Gloucestershire; Crayford and Erith brick-earth; Kesh caves, Co. Sligo, Ireland (where *Dicrostonyx* was very numerous in some strata), and from France.

The other species, *Dicrostonyx henseli* of Hinton (*op. cit.*, 37), described from a skull in the collection of Abbott, from Ightham Fissures, Kent, has also been identified from the Arctic Bed of Angel Road, Tottenham, Middlesex (Hinton, *Quart. Journ. Geol. Soc.*, June 1912, 249); Langwith Cave, Derbyshire; Doneraile Cave, Co. Cork (where *Dicrostonyx* occurred with *Lemmus* in enormous numbers, see Ussher, *op. cit. supra*, p. 394); as well as from Quedlinburg (Hensel's original skull of *ambiguus*, the dental peculiarities of which were noticed by its discoverer). This is a small species with reduced tooth-pattern, m^1 and m^2 lacking the minute postero-internal salient angles, and having the posterior wall of the postero-external triangle reduced; it thus resembles rather *D. hudsonius* of Labrador, but is smaller than that species; it has also less expanded nasals, the presphenoid bone is reduced to a mere rod, and the teeth are heavier.

Remains from the following localities have not been assigned

[1] *Arvicola gulielmi*, Sanford, *Quart. Journ. Geol. Soc.*, xxv., 1870, 125, pl. viii., figs. 4 and 4a.

to particular species:—Murston, near Sittingbourne, Kent (Newton); Fisherton River, near Salisbury (Blackmore and Alston); Dog Holes, Warton Crag, Lancashire (Jackson); Corstorphine, Edinburgh (mandible found by Bennie and identified by Newton—see *Scott. Nat.*, 1913, 97-100, where W. Evans mentions another Scottish find, to be recorded later by Horne and Peach); and the Irish caves of Co. Clare. As with the Norwegian Lemming, the bones are sometimes remarkably fresh, noticeably those from the Co. Clare caves.

The absence of *Dicrostonyx* from Skandinavia is remarkable in contrast to the almost entire restriction therein of *L. lemmus*. If *Lemmus* reached Skandinavia from the west, it is difficult to understand why *Dicrostonyx* failed to do so. It looks as if *Lemmus* had ousted the more specialised *Dicrostonyx* in Western Europe. The fact that *Dicrostonyx* was evidently unable to enter Skandinavia from the east or south, favours the truth of the suggestion of the western origin of *Lemmus* in Skandinavia.]

Group MICROTI.

VOLES OR VOLE-MICE.

The mice of this group are generally known in recent zoological works as "voles" or "vole-mice." Vole = "a field" is an abbreviation of "vole-mouse" = "field-mouse," a north English word used by Barry (1805) for the Orkney species (compare Norwegian "voll," Icelandic "voell-r"). The word is often incorrectly used, especially in such cases as "Field Vole" = "Field Field"! For this reason it is, perhaps, fortunate that it has not reached the general public, but is confined to zoological works. Its use ought to be restricted by naturalists, a course which may, perhaps, be best followed by retaining it for the group *Microti*, in which sense its application is convenient, and discarding it from the actual species.

The majority of voles may be distinguished at a glance from lemmings by their smaller head, more slender body, thicker fur, and longer ears and tail; the latter is (except in *Lagurus*) much

longer than a hind foot, and thus intermediate between those of lemmings and true mice. In their more ordinary hands and feet the palms and soles are provided with pads. Voles are thus externally less specialised, but cannot be absolutely separated from the lemmings, since a few members of either group exhibit the characters of the other. The **fur** is usually soft, the **colours** rarely bright. The **skull** is comparatively slender and lightly built. In the **teeth** the lower incisors are long, and the extremities of their roots lie on the outer sides of their m_3; the cheek-teeth have the dentine-spaces subequal, and their upper crowns become distinctly narrower from front to back.

These are hardy animals, never hibernating, and continuing their activity in winter beneath the snow of boreal countries.

The group is of wide and almost ubiquitous distribution in the extra-tropical regions of the Northern Hemisphere, where a number of genera have been for the most part recently differentiated. There are several British species, which fall into three existing genera (*Evotomys*, *Microtus*, *Arvicola*); a single extinct genus (*Mimomys*); and a genus and sub-genus (*Pitymys* and *Chionomys*), extinct in Britain, but still existing in continental Europe.

GENUS EVOTOMYS.

1811. MYODES, P. S. Pallas, *Zoographia Rosso-Asiatica*, i., 173, based on *Mus lemmus* of Linnæus, hence antedated by LEMMUS, Link, 1795; de Sélys-Longchamps, *Études de Micromammalogie*, 1839, 87, section based on *Lemmus rubidus* of Baillon, 1834 = *Mus glareolus* of Schreber; Lataste, *Le Naturaliste*, 15th October 1883, 349, sub-genus based on *Mus rutilus* of Pallas = *Evotomys rutilus*.

1831. HYPUDÆUS, misprinted HYPUDACUS (col. 874) and HYPUDEUS, (pl. vii.), E. Mehlis, Oken's *Isis*, viii., based on *H. hercynicus* of Mehlis = *Mus glareolus* of Schreber; Keyserling and Blasius, *Die Wirbelthiere Europa's*, 1840, viii., and 34, sub-genus based on *Mus glareolus* of Schreber; preoccupied by HYPUDÆUS of Illiger, *Prodromus Syst. Mamm. et Avium*, 1811, 87; the latter based on *Mus lemmus* of Linnæus, hence antedated by LEMMUS, Link, 1795.

1874. EVOTOMYS, Elliott Coues, *Proc. Acad. Nat. Sci.* (Philadelphia), 186; genus based on *Mus rutilus* of Pallas.

1900. EUOTOMYS, Erwin Schultz, *Zeitschr. für Naturwiss.* (Stuttgart), 19th December, 203; Collett.

1900. CRASEOMYS, G. S. Miller, *Proc. Wash. Acad. Sci.*, ii., 87, a sub-genus of EVOTOMYS based on *Hypudæus rufocanus* of Sundevall; Thomas, *Proc. Zool. Soc.* (London), 1906, 863 (genus).

1902. EOTOMYS, C. J. Forsyth Major, *Proc. Zool. Soc.* (London), i., 107, a misprint.

1905. PHAULOMYS, Oldfield Thomas, *Ann. and Mag. Nat. Hist.*, May, 493; a sub-genus of EVOTOMYS based on *E. smithii* of Thomas.

Although but recently defined, the genus *Evotomys* has been universally accepted, and (neglecting Mehlis's misprint) there can be no doubt about its correct name. It includes a number of somewhat generalised and primitive species, presenting external characters, as in the proportions of the eyes, ears, and tail, somewhat intermediate between lemmings, voles, and true mice. The roots of the cheek-teeth recall the murines. The lower incisors pass each to the buccal side of its m_3, as in other *Microti*, but at a lower level, so that the latter tooth is not so markedly displaced. The tendency to adopt a rufous mantle arising from a dull or plumbeous juvenile pelage is a development on specialised and perhaps peculiar lines.

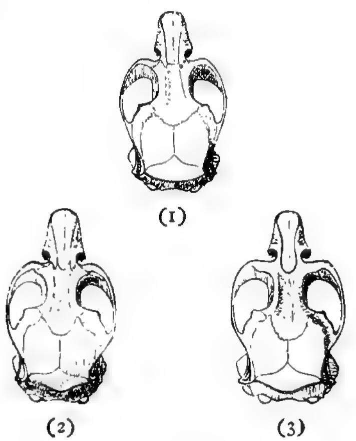

FIG. 59.—SKULLS OF BRITISH *Evotomys* from above—(1) *E. glareolus britannicus*, old, the cheek-teeth with long roots; (2) *E. alstoni*, old, the cheek-teeth with long roots; (3) *E. skomerensis*, adult, the cheek-teeth with short roots; natural size. (Drawn by M. A. C. Hinton.)

Although enjoying green food these mice are not restricted to the surface of the ground. They run more actively than *Microtus*, jump moderately well, but are unable to bound like *Apodemus*. They are fond of woods, where they climb trees, though not to great heights, devouring berries, fruits, and bark, and in cold countries amass stores of provisions. They may also eat invertebrates, and, when opportunity offers, young birds or small mammals. They swim well, and inhabit a variety of situations, from sandhills on the sea-coasts to mountains. In the north they may in winter occupy a position resembling that of the House Mouse of temperate regions.

Characters:—With a few exceptions, they resemble typical *Microtinæ*, but are lighter, more elegantly built, and have the dorsal surface usually of some shade of rufous; deeper and richer in humid, wooded regions, lighter and yellower with a tendency to winter whitening in the north. The eyes and more or less circular ears tend to be more conspicuous than in *Microtus*; the feet are small, with normal pads; the tail is shorter than in murines, longer than in *Microtus*; the fur is long and soft in winter, shorter and harsher in summer. The **mammæ** are 8, viz., 4 inguinal and 4 pectoral.

The **skull** shows some murine characters, being comparatively weak, and lacking in angularity. The outlines are full and rounded, the ridges, even in old age, slightly developed. The interorbital region is broad, the auditory bullæ large and comparatively inflated.

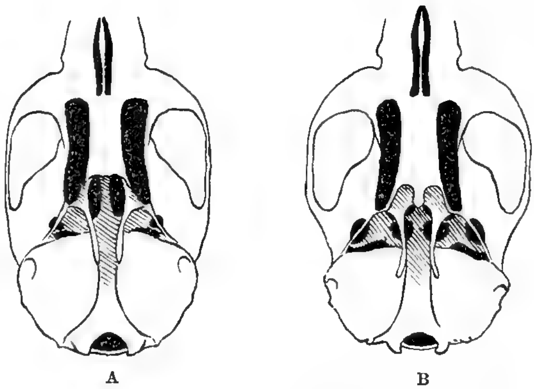

FIG. 60.—PALATE OF (A) *Evotomys*; (B) *Microtus* (diagrammatic and magnified).

The zygomata are usually slender, and scarcely widened in the regions where the jugals and zygomatic processes of the maxillaries meet; the mandible is slender and weak. The bony palate lacks the sloping part of the posterior median ridge, and shows little trace of the lateral pits, both so characteristic of *Microtus*; it thus terminates in a thin-edged shelf continuous between the alveoli of the posterior cheek-teeth. This arrangement was at first thought to be highly characteristic, but has since been found in other genera, as *Anteliomys* and *Eothenomys*.

The incisors are weak and slender, and those of the mandible run back, each along the lingual sides of its first and second cheek-teeth, crossing the tooth-row behind the latter, and terminating in the ascending ramus of the mandible distinctly below the dental foramen; not rising above the level

of the cutting surface of the cheek-teeth nor forming a protuberance on the outer surface of the mandible.

The cheek-teeth are small, narrow, weak, and, in the young, rootless. Their growth from a rootless to a rooted condition causes great changes in the enamel pattern, which gradually loses its definiteness, and finally disappears. In the young teeth the dentine-spaces extend to the base; at which a ring forms later, then contracts and divides into two, each half becoming a broad root as the tooth is pushed upwards. When immature the enamel is thin, the salient angles sharp, the infolds wide and shallow, and consequently the dentinal spaces confluent. When adult the enamel is thick, the tips of the salient angles rounded, and the infolds deeper. The elements of the teeth are

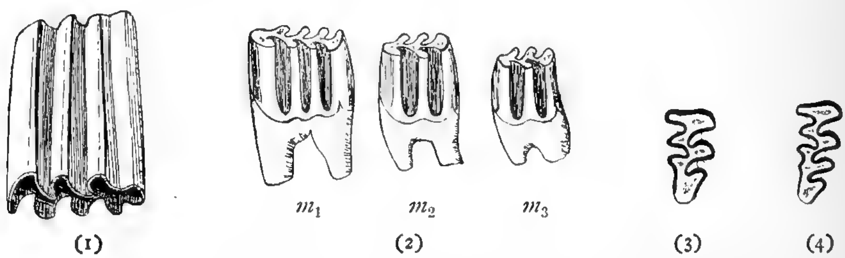

FIG. 61.—(1) ANTERIOR LEFT LOWER CHEEK-TOOTH OF *Arvicola amphibius*, tilted so as to show open pulp cavities. (2) LEFT LOWER CHEEK-TEETH OF *Evotomys glareolus*, both seen from outer side. (3) *E. glareolus*, simple form of m^3. (4) *E. skomerensis*, complex m^3. (Drawn by M. A. C. Hinton.)

crowded longitudinally, so that the alternation of the inner and outer triangles tends to be inconspicuous; further, the outer infolds of the lower teeth are usually shallow, so that each pair of prisms tends to form a transverse loop rather than an inner and an outer closed triangle. These features are characteristic of all the normal members of the genus. m^1 and m^2 are of normal form, having the anterior loop followed by four and three substantially closed triangles respectively; the outer triangles are in each tooth slightly larger than the inner. In m^3 the anterior loop precedes two outer and one inner prisms, followed by a posterior loop of variable shape; the inner prism is usually closed, but all three may be closed or open, leaving a continuous dentine area along the centre of the crown; the inner is usually the largest, the postero-external the smallest.

The posterior loop may be simple or complicated by the presence of extra infolds — generally a shallow antero-external and a deep internal[1]—the latter extending across the tooth nearly to the enamel of the outer side; there are many intermediate conditions, but in the simplest form there are on each side three salient angles and two infolds; in the most complicated form there are four or five salient angles and four infolds on each side.

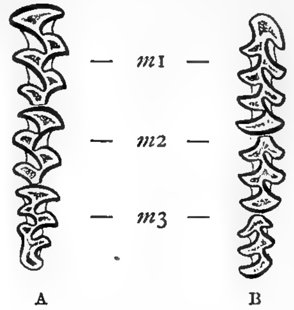

FIG. 62.—RIGHT CHEEK-TEETH OF *Evotomys glareolus* (A, upper; B, lower; crown view; 7 times life size).

In m_1 the posterior transverse loop is preceded by two outer and three inner more or less closed triangles; the tooth has thus four outer and four or five inner salient angles; the third inner triangle opens more or less broadly into the short anterior loop, which presents externally a well-marked salient angle, while its inner border may form another salient angle or may be rounded and only slightly salient.

m_2 and m_3 are composed each of three more or less transverse dentine-loops, giving rise to six salient angles and four infolds; those of the outer side are poorly developed, especially in the m_3, in which when well-worn the anterior angle and infold may be absent. The first and second loops of m_2, and the second loop of m_3, especially the former, may be partially or completely divided into triangles.

The **sub-genera** *Craseomys* and *Phaulomys* indicate advanced specialisation, but seem to be rather of "group" than of higher value (see Anderson, *Ann. and Mag. Nat. Hist.*, Oct. 1909, 317, and May 1905, 493).

The genus contains a number of species, of circumpolar **distribution**, from the shores of the Polar Sea (introduced in Bering Island) through arctic, boreal, transitional, and sometimes subtropical zones, but absent from Greenland, the islands of the Polar Sea, Newfoundland, Spitzbergen, Novaya Zemlya, and Iceland. South it ranges in North America to

[1] This is variably developed in the different species; it is present in about 25 per cent. of *E. g. britannicus*.

the mountains of North Carolina and Colorado, with the sea-coasts of New Jersey and Northern Carolina; and in Europe to the Pyrenees (*not* in Iberia), the mountains of southern Italy, Rumania, and Trebizond. In Asia, it reaches the Thian-Shan and Kinghan Mountains of Mongolia; Pekin and the Shansi Mountains (8000 feet) of North China; Korea, Sakhalin, and Japan, from Hokkaido (Yezo), to Kiushiu.

Its southern habitats are usually in mountains (as *E. nageri hallucalis* of southern Italy and *E. brevicaudus* of Black Hills, S. Dakota), where they may be quite isolated; and in North America these detached colonies have been found in what are practically cool faunal islands surrounded by warmer zones far south of the ordinary range of their species (see Miller, *Science*, 4th November 1898, 615-616).

E. smithii is remarkable because, although a member of an hypothetically "arctic" genus, abundant in the British Pleistocene, and at Ightham accompanying such nominally "arctic" forms as *Lemmus* and *Dicrostonyx*, it is common in the two semi-tropical islands of Shikoku and Kiushiu, Japan (Thomas, *Proc. Zool. Soc.*, London, 1905, ii., 355). Thus, in *Evotomys*, as in true *Lepus*, the various species may be found in very different climates, so that the occurrence of a member of the genus in any particular geological deposit cannot in itself be regarded as evidence of climate.

Distribution in time:—The earliest remains of the genus yet discovered are those from the late pliocene Forest Bed of Norfolk. Others are known from the High and earlier Middle Terrace deposits of the Thames valley (lower and middle Pleistocene), but all are too fragmentary for specific determination.

Origin:—As a circumpolar genus, *Evotomys* may be compared with (restricted) *Lepus*, especially in its isolated southern colonies, its absence from North Africa and presence in Japan, but in the latter country it ranges much farther south than *Lepus*. Unlike *Lepus*, it is a generalised type, which no doubt largely accounts for its survival against the competition of modern forms. Like *Lepus*, its more specialised representatives have now become restricted to inhospitable arctic regions, mountains or islands. Like *Lepus*, it is older than the separa-

tion of the Old and New Worlds, and its presence in Kiushiu, but absence from Newfoundland, Greenland, and Iceland, suggest an Asiatic origin with dispersal to North America by an old land connection across Bering Sea.

THE BANK MOUSE.[1]

EVOTOMYS GLAREOLUS (Schreber).

EVOTOMYS GLAREOLUS BRITANNICUS[2] (Miller).

1774. MUS GLAREOLUS (species), J. C. D. von Schreber, *Die Saugthiere*, iv., 680, pl. 190 B; described from Laaland Island, Denmark.

1831. HYPUDACUS (misprint for HYPUDÆUS) HERCYNICUS (species), E. Mehlis, Oken's *Isis*, viii., 876; described from the higher Harz Mountains, Germany (HYPUDÆUS and HYPUDEUS occur also in the same article).

1834. HYPUDÆUS GLAREOLUS (species), H. B. Melchior, *Den danske Stats og Norges Pattedyr*, 116; identifying *Mus glareolus* of Schreber.

1832. ARVICOLA RIPARIA, William Yarrell, *Proc. Zool. Soc.* (London), 22nd May, 109, and Loudon's *Mag. Nat. Hist.*, v., 1832, 599; described from Birchanger, Essex, England; preoccupied by *Arvicola riparius*, Ord, 1825 = *Microtus pennsylvanicus* (Ord) of North America; Jenyns.

1837. ARVICOLA PRATENSIS, Thomas Bell, *History of British Quadrupeds*, ed. i., 330; Boyd Dawkins and Sanford, *British Pleistocene Mammalia*, 1866, xiv and xxxvi (? part); Boyd Dawkins, "Distribution of the British Post-Glacial Mammals," *Quart. Journ. Geol. Soc.*, xxv., 1869, 194 and 196 (? part); MacGillivray; Owen (? part); Morris, *Cat. Brit. Foss.*, ed. ii., 1854, 357 (? part); from F. Cuvier's *Hist. Nat. des Mammifères*, vii., *Tab. Gen. et Méth.*, 1842 (described and figured in livr. 68, 1834) = *E. glareolus* (Schreber).

1870. ARVICOLA GLAREOLUS, W. A. Sanford, *Quart. Journ. Geol. Soc.*, xxvi., i., 124 (? part); Blackmore and Alston, *Proc. Zool. Soc.* (London), 16th June 1874, 461 (? part); Alston, in Bell, ed. ii., 1874; Newton, *Vertebrata of Forest Bed*, 1882, 82, pl. xiv., fig. 1 (? part); Lydekker, *Cat. Foss. Mamm. Brit. Mus.*, i., 233, 1885 (? part); Flower and Lydekker (? part); Harting, *Zoologist*, 1887, 361, pl. v.

1881. ? ARVICOLA (EVOTOMYS) GLAREOLA (part), E. T. Newton, *Geol. Mag.*, June, 258.

1890. MICROTUS GLAREOLUS (part), A. Smith Woodward and C. D. Sherborn, *Cat. British Fossil Vertebrata*, 365; Lydekker; Aflalo.

1898. EVOTOMYS GLAREOLUS, Oldfield Thomas, *Zoologist*, 101; Johnston; Miller, *Ann. and Mag. Nat. Hist.*, 1909, 419; Pycraft, British Museum *Guide to British Vertebrates;* Millais.

1900. EVOTOMYS HERCYNICUS BRITTANICUS (*sic*), G. S. Miller, *Proc. Wash. Acad. Sci.*, ii., 26th July, 103; described from Basingstoke, Hampshire.

1903. EVOTOMYS GLAREOLUS BRITANNICUS, G. E. H. Barrett-Hamilton, *Proc. Roy. Irish Acad.*, 11th May, 317; Miller (*Catalogue*).

1910. EVOTOMYS GLAREOLUS BRITANNICUS, E. L. Trouessart, *Faune des Mammifères d'Europe*, 170.

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[1] Bank or Red Vole of authors.

[2] First spelt *brittanicus*, but later corrected by the author to *britannicus*.

Synonymy:—The first three items refer to the species *glareolus*; the remainder to the British sub-species *britannicus*. Schreber's description and figure of *glareolus* are so poor that doubts have been expressed (by Miller) as to the identity of the animal thus named, but, since Melchior applied the name *glareolus* to the Danish *Evotomys*, and nothing in Schreber's description is inconsistent with Melchior's determination, the name, which has been widely accepted, is entitled to stand, thus avoiding resuscitation of Melchior's *hercynicus*. The species was mentioned for the first time by Pallas (*Novæ Species Quad e Glirium*, 247), who considered it a variety of his *Mus rutilus*.

Terminology and local names:—The species is not distinguished locally, the following being merely book names:—Bank Campagnol (translating the technical name *riparia*), Yarrell, 1832; Jenyns, 1835. Bank Vole, Bell, ed. i., 1837, and ed. ii., 1874; Lydekker, 1895; Thomas, 1898; Johnston, 1903; Millais, 1905; and most modern authors. Red or Meadow Vole, MacGillivray, 1838. Red Field Vole, Alston, in Bell, ed. ii., 1874. Red Vole or Wood Vole, Johnston, 1903. Red-backed Meadow-Mouse, English. Red-backed Mouse of American writers. The word "vole" being, as explained above (p. 398), objectionable, the name "Bank Mouse" would seem to be appropriate.

History and status:—The Bank Mouse of Britain was first described in 1832 by Yarrell, who believed it to be new to science. Soon afterwards, specimens were forthcoming from several counties, and Bell rightly referred them to the present species already known by several synonyms. Jenyns also reached the same conclusion (*Ann. and Mag. Nat. Hist.*, June 1841, 270) after examining one taken by William Thompson at Aberarder, Inverness-shire (see Charlesworth's *Mag. Nat. Hist.*, 2nd ser., iii., 1839, 585). Other early discoverers of it were Selby in Northumberland (*Mag. Zool. and Bot.*, ii., 1838, 92); Eyton in Shropshire (*Ann. Nat. Hist.*, Feb. 1840, 397), and Bond in Middlesex (*Zoologist*, 1887, 425). In Scotland it was first identified by MacGillivray, who, previously to 1838, examined specimens taken by Weir at Bathgate, Linlithgowshire; Edward also found it in Banffshire (Smiles's *Life of a Scotch Naturalist*, ed. i., 1876, App., 393). It was long reputed a rarity, as shown by the comparatively recent dates of first records for many counties where it is now well known, and it was not until after the introduction of efficient methods of trapping that its status in Britain was recognised. Although far below specific rank, the British Bank Mouse is, from its deep coloration, an easily recognisable sub-species when a series of specimens are examined.

Distribution:—The species *glareolus* is found usually in wooded districts, but not in the higher mountains, through boreal and temperate Europe, exclusive of the Iberian Peninsula, from Scotland, Skandinavia,

and corresponding latitudes in Russia, south to the Pyrenees, southern Italy, and Rumania; east and west it ranges from Wales, at least to the Syansk Mountains, 100 miles west of Lake Baikal, where it ascends to 1600 feet.

The sub-species *britannicus* is confined to **Britain.** It is absent from Ireland, the Isle of Man, the Hebrides, Orkneys, and Shetlands; but is common throughout England, Wales, the lowlands of Scotland, and north to the districts adjoining the south coast of the Moray Firth, with the islands of Anglesey (Oldham), Wight (More), and Bute. It does not ascend the mountains to any great height, though on the latter point details are lacking for England and Wales (recorded from 600 feet in Cheshire by Coward; and 700 feet near Bridge of Allan, W. Evans, *MS.*). In Scotland it is characteristic of the valleys and cultivated districts rather than the moors and uplands, where it gives way to *Microtus;* when found on the moors it affects the boulder-strewn hollows rather than the open ground (Gordon). Its distribution has not yet been worked out for the Highlands, where it may eventually prove to be more common than the present meagre records would warrant. For instance, at Loch Awe, Argyll, the first record was that of C. H. Alston in *Ann. Scott. Nat. Hist.*, 1905, 52; the mouse had been previously unnoticed, yet it is much commoner than *Microtus* (Alston, *MS.*). It is not yet known from Sutherland or Caithness, the most northern record being that of Hinxman and Clarke for Braemore, West Ross-shire (*Proc. Roy. Phys. Soc.*, Edinburgh, 12th June 1894, 394); this fact, taken in conjunction with Cocks's experience in Buckinghamshire, suggests that this may actually be an increasing species, which may really have been rare until recent years.

Distribution in time and origin:—*E. glareolus* is not known earlier than the late pleistocene fauna of Ightham, Kent, where it occurs, as a distinct sub-species, with other forms now extinct. Its present distribution and absence from Spain indicate a recent arrival from the East, which reached Britain before the separation of Anglesey, Wight, and Bute, but after that of Ireland, Man, and the Scottish Islands. It does not yet seem to have had time to thoroughly overrun Scotland.

Description:—The general appearance of the Bank Mouse has been indicated above under the genus *Evotomys.*

The sparsely-haired ears are usually described as longer than in the Grass Mouse, but actually owe their conspicuousness rather to the shorter fur, which they overtop, than to any proportionately larger size; when laid forward they do not quite reach to the eyes. The densely-haired tail has a distinct terminal pencil, and reaches a length about half that of the head and body. The muzzle-pad is small and inconspicuous, and is crossed by a narrow median cleft running upwards from the upper lip. The lips are pink. In each hand the thumb is

rudimentary, with minute nail. Digit five reaches to the base of four; three is slightly longer than four, and four than two. There are five large normally placed pads; the intervening skin is finely tuberculo-reticulate. In each foot the hallux reaches to the base of digit two; digit five slightly beyond the base of four; four, three, and two are subequal in order of length. There are six normally placed pads, smaller than those of the hand, especially the posterior; the intervening sole is naked and tuberculo-reticulate, densely haired behind.

Colour:—The reddish mantle extends from the forehead in front of the eyes to the base of the tail, and is usually near "vandyke brown," strongly washed with "cinnamon rufous," and sprinkled with longer black hairs; the flanks, cheeks, and the face before the eyes are lighter. There is no distinct line of demarcation. The under side is whitish, frequently washed to a variable extent with yellowish or buff; the feet are greyish, the tail inconspicuously bicoloured. The colours are lighter red when faded, as in late winter.

The carpal vibrissæ appear with the first pelage in the nest. The whiskers reach a length of from 22 to 28 mm.

Moult; a coarser coat is assumed in October, after which in cold localities the flanks may be greyer, as in *Sciurus*. A moult has also been observed in early May (8th) [and by Collett in July or August in the Norwegian *Evotomys*].

The **young** have the upper side less brightly coloured. In the woolly juvenal coat the under side is at first dusky; later, as longer hairs with light tips increase in number, the characteristic tints of the adult are gradually assumed, at first on the upper side, but a buff or yellowish belly, when present, is characteristic of the adult pelage, hence it is most conspicuous in winter.

There is some **local variation**. Specimens from Scotland (W. Evans) and Anglesey (Oldham, *Zoologist*, 1895, 302) are said to show very dull tints as compared, for instance, with those from near Swansea. At Reigate, Surrey, adults have a greyish-white belly; this is purer white in Hertfordshire, most brilliant in winter (Adams). The subject requires investigation by local naturalists. Occasionally a specimen has the mantle so pale and the sides, cheeks, and face so grey as to recall the coloration of continental sub-species. The most pronounced of these are from Scotland, where also Millais believes that the average size is larger.

For the **skull** and **teeth**, see description of genus *Evotomys*. m^3 is usually simple, having on each side three well-defined salient angles and two infolds.

Exceptional variation:—Forrest has sent me a note of a melanic individual taken at Ellesmere, Shropshire; the whole animal was uniform dull brownish-black. Several entirely or partially albinic

histories of very many others, which were formerly little known, have been fully elucidated, while, speaking generally, an immense increase in our knowledge on such important subjects as Migration, Distribution, Habits, Nidification, Plumages, has accrued: And lastly, a new and important branch of study has been instituted —namely, the recognition of the various Racial Forms or Subspecies exhibited by certain birds in the British Islands, on the Continent, and elsewhere.

A great advance has also been made towards a more satisfactory system of classification of the Aves—always a difficult subject—and this necessitates departures from the older views.

To bring this Standard Work thoroughly abreast of the most recent knowledge in all these departments is the object of the present work.

It should be remarked that while it is not intended to go fully into Synonomy, yet, where changes of nomenclature have been necessary in order to conform with the Law of Priority—the only method by which complete uniformity in nomenclature can ultimately be attained—the names used in the Fourth Edition of Yarrell's "British Birds" and in Saunders' "Manual," and the Trinomial Names of the British Racial Forms, and of those occurring in Britain as visitors from the Continent, will be quoted, as will also the Original Name under which the species was described.

In requesting Mr Eagle Clarke to undertake the duties of Editorship, the Publishers desire to make it known that they are acting under the advice of the late Mr Howard Saunders, who placed all his collected notes for a New Edition at Mr Eagle Clarke's disposal for this purpose. That Mr Eagle Clarke is eminently fitted for the work is well known to all who are interested in ornithological science. Through his investigations of the subject, and contributions to its literature, he has long been recognised as one of the foremost authorities on all that relates to British birds. He has studied our native birds in many portions of the British Islands, and has visited a number of bird-haunts in various parts of Europe in order to become acquainted in their Continental homes with the visitants that seek our shores.

On the important matter of the Migrations performed by British Birds, Mr Eagle Clarke's knowledge is unrivalled—a material fact, when it is called to mind how little has been said on this most important subject in any published History of British Birds.

A new and important feature of the New Work will be a Coloured Plate of each species. These will be reproduced in the best style from original drawings specially executed for the work by Miss Lilian Medland, F.Z.S., an accomplished and well-known bird artist.

GURNEY & JACKSON

33 PATERNOSTER ROW, LONDON, E.C.

Oliver and Boyd, Printers, Edinburgh.

PART XV.—March 1914 Price 2s. 6d. net.

A HISTORY OF BRITISH MAMMALS

BY

GERALD E. H. BARRETT-HAMILTON
B.A. (CANTAB.), M.R.I.A., F.Z.S.

WITH MANY FULL-PAGE PLATES IN COLOUR, IN BLACK AND WHITE, AND NUMEROUS ILLUSTRATIONS IN TEXT

DRAWN BY

EDWARD A. WILSON
B.A., M.B. (CANTAB.)

AND

GUY DOLLMAN
BRITISH MUSEUM OF NATURAL HISTORY

GURNEY AND JACKSON
33 PATERNOSTER ROW, LONDON, E.C.
1914

In Preparation

A NEW AND REVISED EDITION OF
YARRELL, NEWTON, AND SAUNDERS'

HISTORY OF BRITISH BIRDS

EDITED BY

WILLIAM EAGLE CLARKE, F.R.S.E., F.L.S.

Keeper of the Natural History Department, The Royal Scottish Museum; Member of the British Association Committee on the Migration of Birds as Observed on the British and Irish Coasts; Corresponding Fellow of the American Ornithologists' Union; Correspondirender Mitglied des Ornithologischen Vereins in Wien; Membre Honoraire du Bureau Central Ornithologique Hongrois; Member of the British Ornithologists' Union, etc.

ILLUSTRATED BY ORIGINAL COLOURED PLATES OF EACH SPECIES SPECIALLY EXECUTED BY

MISS LILIAN MEDLAND

THE publication of Yarrell's "History of British Birds" was commenced in 1837 and completed in 1843. Its outstanding merits were at once recognised, and a Second Edition was called for in 1845, followed by a third in 1856.

From the issue of the Original Edition down to the present day, Yarrell's "History of British Birds" has generally and deservedly been regarded as the standard authority on British ornithology.

In the year 1871 a Fourth Edition was begun, under the masterly editorship of Professor Newton—the greatest British ornithologist of all time. Unfortunately Professor Newton's official engagements at the University of Cambridge only allowed him to complete the first two volumes; and in 1882 Mr Howard Saunders was selected to edit the remaining volumes, a task which he successfully accomplished to the entire satisfaction of ornithologists in 1885.

The many excellences of this last edition advanced the work more than ever in the public and in scientific favour. To its stimulating influence is to be mainly attributed the marvellous and unprecedented activity which has resulted in those extraordinary advances made in all branches of British ornithology during recent years—advances which have rendered it essential that a new work based upon this classical and comprehensive foundation should be issued.

During the period alluded to, a considerable number of new and interesting species have been added to our avifauna. The

[Continued on Page 3 of Cove

CONTENTS OF PART XV.

The English local names have been revised in part by Mr W. W. Skeat, M.A. (assisted by the late Professor W. W. Skeat), and in part by Mr C. M. Drennan, M.A. Lond., late Scholar Emm. Coll. Camb.; the Celtic and Gaelic names by Dr E. S. Quiggin, M.A., Ph.D., Fellow and Lecturer in Modern Languages and Celtic of Gonville and Caius College, Cambridge; while a list of Scottish Gaelic names has been supplied by Mr C. H. Alston. Valuable assistance has been rendered by Mr M. A. C. Hinton regarding extinct Mammals. Much information has been taken from Mr G. S. Miller's recently published "Catalogue of the Mammals of Western Europe," the use of the MS. and proofs of which before publication was kindly permitted by the Trustees of the British Museum of Natural History.

ILLUSTRATIONS

FULL-PAGE (*Coloured and Black and White*).

FIGURES IN TEXT.

[Photo: Poole, Waterford.

Yrs truly,
C. H. Barrett-Hamilton

GERALD EDWIN HAMILTON BARRETT-HAMILTON

AN APPRECIATION

IN the last number of the *History of British Mammals* there appeared a beautiful appreciation of Edward A. Wilson, the artist and companion in death of Captain Scott, written by the author of the work, and now, to the deep regret of all who knew him, the very next number of his much-loved book has to be prefaced by a notice of Barrett-Hamilton's own death, a death curiously parallel to that of his friend. The two, as Barrett-Hamilton tells us, had known each other from their college days, had both wished to go on Scott's first Antarctic expedition, and each had helped the other in the scientific work which resulted from that first expedition—while from the second there was to be no return for Wilson. But a short period elapsed, and Barrett-Hamilton himself accepted a somewhat similar mission—to go to South Georgia to observe the whale fishery now being carried on in high Southern latitudes with so much success as to threaten the extermination of the whales; to study and note the characters and habits of these animals, and to get what scientific collections he could in that almost Antarctic region. All had gone well to the end of the year, but in January the news was telegraphed home that he had died of heart-failure on the 17th of that month. Barrett-Hamilton, like Wilson, died on duty in obedience to the dictates of that spirit of scientific enterprise which had already caused the loss of his friend.

My own acquaintance with him dated from the same time as Wilson's—his undergraduate days—when I was pleased to see some papers appearing on British Mammals, and hastened to press their author into the service of technical mammalogy, by enlisting his help for the National Museum. For some years while "eating his dinners" for the Bar, Barrett-Hamilton worked regularly at the Museum, taking for his speciality the Palæarctic Mammalia, in the same way as Bonhote was then doing for the Oriental ones, De Winton, Schwann, and Wroughton working in succession at those of Africa. During this period he wrote such monographs as were possible on the material then available, and thus paved the way for the general work on British mammals on which he early set his heart, and which he lived to carry so far that it will remain a monument to his memory, even if the final parts have to be completed by others. It was his early work on European mammals that made it evident that much more material was needed to deal adequately with the subject, and firstly by the late Lord Lilford's generosity, and later by more systematic and official endeavour, the great collection was built up on which Mr G. S. Miller's *Mammals of Western Europe* was based, this book in its turn being constantly called on for help in Barrett-Hamilton's own especial work.

Full of the spirit of adventure, Barrett-Hamilton's scientific life has been interrupted by several missions abroad. These were either in the cause of science, as when he went to the Alaskan seas to study the life-history of seals, and again on the last fatal expedition, or in the national service of his country. For he went to South Africa to serve in the Boer War, an occasion when he by no means forgot his scientific tastes, as he made considerable collections at the dreary outpost where he spent most of his time.

Of late years, after he had married and settled down on his father's estate in Ireland, his visits to the Museum

necessarily became shorter and shorter, often only two or three days in length—days devoted for the most part to the verification of an innumerable mass of references to a mountain of books — while he left Mr Hinton to do some of the laborious comparisons of skulls and teeth, for which he had no longer the time. This collaboration has had the fortunate result that Mr Hinton is now available, and has kindly undertaken to finish the remaining parts of the *History of British Mammals.*

It may be a convenience to naturalists for the formal outlines of our author's life to be recorded here :—

Born 1871 ; only surviving son of Captain Samuel Barrett-Hamilton of Kilmanock, Campile, Co. Wexford, Ireland. Educated at Harrow (captain of football, 1890; played for Old Harrovians for several years). Trinity College, Cambridge (first class Nat. Sci. Tripos, 1894). Called to the Bar, 1896. Member of the Bering Sea Fur-Seal Commission, 1896-7. Served in the Boer War, 1901-2; Captain, 1902. Major 5th Batt. Royal Irish Rifles, 1905. J.P., Co. Wexford. Married 1903, Maud Charlotte, only daughter of F. S. Eland, Esq., of Ravenshill, Transvaal, by whom he leaves six children. Died in South Georgia, 17th Jan., 1914.

As a personality, Barrett-Hamilton was one of the most pleasant companions it has ever been our good fortune to meet. Warm-hearted, full of fun, known to all of us by a nickname, ready to engage in anything from a game of football at the back of the Museum to a discussion on nomenclature or dentition, the happy-minded lovable Irishman was a favourite with the whole staff of the Museum. Deeply will he be missed by all of us, and by none more than the writer of this short notice, who loses in him a dear and intimate friend of twenty years' standing.

OLDFIELD THOMAS.

PLATE XXVI.

THE WATER RAT.

(1) LEFT EAR ($2\frac{1}{2}$ times life size); (2) LEFT HAND and (3) LEFT FOOT (both $1\frac{1}{2}$ times life size); (4) TAIL, viewed from above (life size). a = anterior; p = posterior.

specimens have been recorded; *e.g.*, (1) cream-coloured, from Hertfordshire, in J. Whitaker's collection; (2) with white patch on head (D'Urban, *Zoologist*, 1879, 265); (3) white with pink eyes and light sandy tint on back, Essex, identified by Bartlett (Rosling, *Journ. cit.*, 1885, 433); (4) light cream with red eyes, Huntingdonshire (Bond, *Journ. cit.*, 1887, 425); (5) white female with slight rufous tinge on upper side, Bedfordshire, No. 98.2.27.1 of British Museum collection.

Geographical variation: — The following may be regarded as sub-species:—(1) *E. g. glareolus* (Schreber) of West-Central Europe, from the Baltic to the Alps and Pyrenees and from the Atlantic coast to Silesia, is brighter in colour, and perhaps on the average (hind foot, 16·6 to 18; condylo-basal length of skull, 23 to 24·6 mm.) slightly larger than (2) *E. g. britannicus*. (3) *E. g. suecicus* (Miller) of the Swedish and Finnish lowlands with the south-eastern watershed of Norway, has the red mantle narrower and the sides and face greyer than in *E. g. glareolus*. (4) *E. g. istericus* (Miller) of the Danube basin, from Bavaria through Hungary to Rumania, and probably to Bulgaria and the Black Sea coast, has also a narrow mantle, but is lighter and yellower, and has the auditory bullæ more abruptly inflated on the inner side. (5) *E. g. helveticus* (Miller) of the Jura Mountains, the non-Alpine parts of Switzerland, and the lower western French Alps, is a pale buffy-grey form with the hind foot 17 to 19 and the condylo-basal length of skull 23 to 25·4 mm. (6) *E. g. saianicus* (Thomas) of the Syansk Mountains, Lake Baikal, is a small grey form with short brain-case, hind foot 16, and condylo-basal length of skull 23 mm.

DIMENSIONS IN MILLIMETRES AND WEIGHT IN GRAMMES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
SPECIMENS FROM REIGATE, SURREY, CAUGHT AND MEASURED BY L. E. ADAMS.*					
SEXUALLY IMMATURE OF BOTH SEXES:—					
1. Male, 20th Sept. 1909, caught running in lane; juvenal pelage	63	29	17	..	..
2. Male, 7th Oct. 1909; found dead; juvenal pelage	64	30	15	..	..
3. Male, 25th June 1909	65	33	15	..	..
4. Female, 5th Aug. 1909; juvenal pelage	72	35	16	..	12
5 Male, 17th Jan. 1909; juvenal pelage	73	40	16	..	12
6. Male, 20th Sept. 1911; adult pelage	74	41	15	10	12
7. Male, 21st Jan. 1909; almost adult pelage	75	39	16·5	..	13
8. Male, 7th June 1911; juvenal pelage	75	35	16	10	9
9. Male, 10th Oct. 1912	78	39	15	9	12
10. Female, 10th Oct. 1912	90	46	17	10	20

* Adams's results agree closely with those of other observers, as Hollis (MS.) in Devon, and with the average for all Britain, as shown by specimens in the British Museum; they may fairly be taken as representative for the sub-species *britannicus*. All the specimens were dissected.

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
SPECIMENS FROM REIGATE, SURREY (*continued*).					
SEXUALLY MATURE MALES:—					
1	96	48	16·5	11	22
2.	95	46	16	10·5	21
3.	88	42	16	10	18
4.	100	47	16	11	20
5.	95	47	16	11	19
6.	88	48	15·5	12	20
7.	97	50	15	12	23·5
8.	85	46	15	11	16·5
9.	92	48	16	11	22·5
10.	90	47	16	11	17
11.	90	40	15	10	16
12.	88	41	17	11	17
13.	92	43	16	11	19·5
14.	89	45	17	10	16
15.	93	47	17	12	17
16.	90	47	17	11	19
17.	88	50	17	11	17
18.	86	55	17	11	18
19.	88	43	16	10	16
20.	90	45	17	11	17
Average	91	46·2	16·2	11 (nearly)	18·6
Average of 36, from various localities, in British Museum	93	43	16·25	11	..
Maximum of 36, from various localities, in British Museum	104	55	18	12	..
SEXUALLY MATURE FEMALES:—					
1.	95	45	16	12	21·5
2.	95	49	16	11·5	21
3.	105	45	16	13	23
4.	100	52	16	11	23
5.	100	51	17	11·5	21
6.	97	55	15·5	12	23
7.	86	40	17	11	17
8.	93	46	16	11	17·5
9.	90	41	16	12	22
10.	90	47	16	11	18
11.	103	53	16·5	13	26
12.	94	51	16	11	20
13.	85	43	16	11	16
14.	86	49	17	12	17
15.	84	44	17	12	14·5
16.	93	49	17	11·5	21
17.	90	46	17	11	16
18.	96	56	17	12	22
19.	89	46	16	11·5	20
20.	81	44	16	11	17
Average	92·6	47·5	16·3	11·6	19·8
Average of 38, from various localities, in British Museum	93	43	16·25	11	..
Maximum of 38, from various localities, in British Museum	117 *	51	18	13	..

* One, Kent, 114 (converted from inches; see Grabham, *Zoologist*, 1896, 497).

Remarks.—Adams finds young in the nurseries until their external dimensions reach about 65-33-15; they then run about and may be trapped, so they are presumably about fourteen days old (see Roberts's observations below on p. 417). Many remain sexually immature until the head and body reach 85; Adams examined one breeding female

of 81; another of 85 contained two embryos. At about 85 adult pelage is assumed, and from 90 upwards the majority are sexually mature. Many grow on to a much greater size, and, in exceptional cases, females have been found to be sexually immature at 97 or 99. It is not clear whether dimensions exceeding 100 are abnormal, or whether every individual would reach that size if not previously destroyed. Apparently they continue to grow for a long time, and Millais finds that all *Microti* improve considerably in colour and size until they are two years old. There is nothing to show that the sexes differ constantly in size.

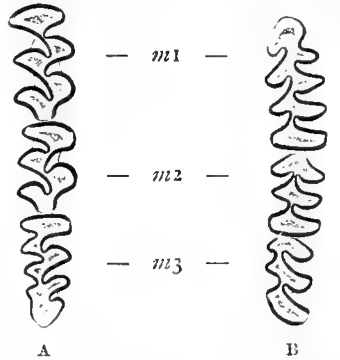


FIG. 63.—CHEEK-TEETH OF *Evotomys skomerensis* (A, right upper; B, left lower; 7 times life size). (Drawn by M. A. C. Hinton.)

Skull:—Condylo-basal length, 21·2 to 24·2; breadth at zygomata, 12·2 to 14; at inter-orbital constriction, 3·6 to 4·2; at occiput, 10·7 to 11·8; median occipital depth, 5·8 to 6·4; greatest length of nasals, 5·6 to 7·4; of diastema, 5·6 to 7·2; of mandible, 12·8 to 14·8; of maxillary tooth-row, 4·8 to 5·6; of mandibular tooth-row, 4·8 to 5·4.

Distinguishing characters:—As between mice of this genus and others of similar size, the hairy, bicoloured tail is probably the most distinctive external character. Its length, about half that of the head and body, is greater than that of any *Microtus*, shorter than that of any member of the sub-family *Murinæ*. In the skull the simple palate, rooted cheek-teeth with rounded salient angles, and transversely open triangles of m_2 are diagnostic. The characters of the other species of *Evotomys* are given under their special headings.

The Bank Mouse[1] is not specialised by its structure for a narrow type of existence. Its habits are, therefore, of comparatively wide range, but not strikingly peculiar in any particular direction. It may be found in all the situations ordinarily affected by Grass Mice or Field Mice, without, however, adopting the extreme rôle of either. In demeanour and activity it is quite intermediate, being less fossorial, but much more rapid and agile in all its movements, than the Grass

[1] Of earlier original accounts that of E. R. Alston, in Bell's second edition, usually, but incorrectly attributed to Bell himself, is, considering the date, 1874, perhaps the best. Other original accounts are those of G. T. Rope, *Science Gossip*, July 1886, 155-7; and of Douglas English, *Some Smaller British Mammals* (undated).

Mouse. On the other hand, although quick and sprightly, a capable climber and a fair jumper, it is in all these respects quite inferior to the Field Mouse.

As an instance of its powers of running, Mr Rope reminds me of the speed with which it will cross a road; and Mr English knew one to escape from a square biscuit-tin, with sides $9\frac{1}{4}$ in. high, that being about the limit of leap attainable by the species, though 7 in. is well within its average powers.[1] The same writer finds it gnawing through wood as rapidly as a House Mouse.

It is active at intervals throughout the day as well as at night; its most favoured haunts being hedgerows, railway-banks, old walls, woods[2] or gardens, especially where the presence of roots, stones, heaps of sticks, or recesses makes the construction of runs easy. It usually prefers warm, dry, sunny situations, yet frequently inhabits wet localities. It swims well, and has been known to escape pursuit[3] by diving, or to recover grains of maize from the bottom of a feeding-trough.[4] Charles St John[5] seems to have met with it living on sandhills by the seashore, where he suggested that its food is grass seeds and dead fish.[6]

[1] F. Head (*Zoologist*, 1888, 24) credits it with springs of a foot upwards, and a similar distance was recorded for its leaps from shelf to shelf of a greenhouse by G. Dalgliesh (*Journ. cit.*, 1907, 302).

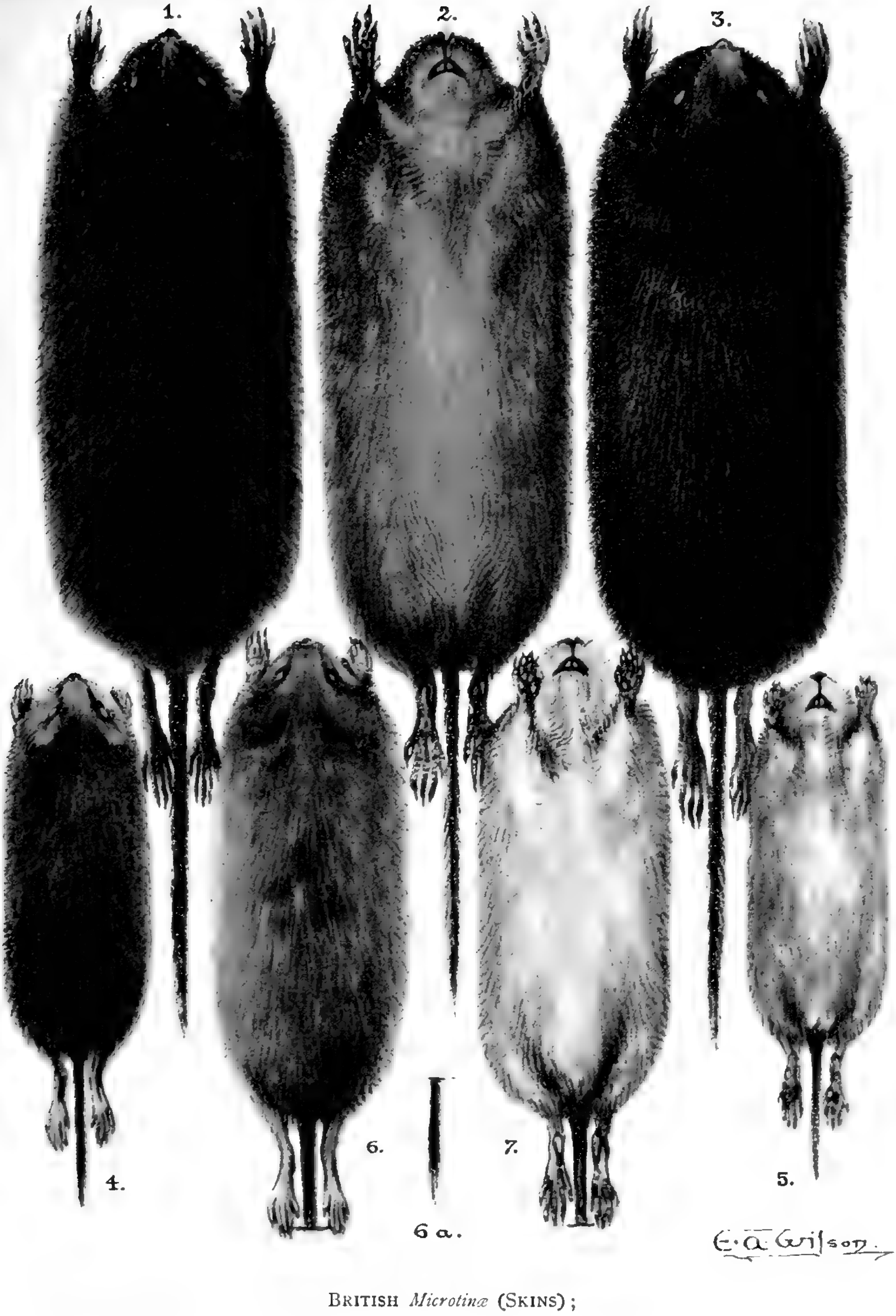
[2] Hence its rufous dorsal mantle is thought by some writers to be protective, as harmonising with a background of dead leaves (Ernest Thompson Seton, I, 509). If so, it is curiously different from the tints of other small mammals, such as shrews, which live amongst similar surroundings. Arising as it does from a dull-coloured juvenile pelage, and being characteristic of the genus in many varying climates and environments, it seems difficult to say more than that it is an indefinite colour, the exact tint of which depends on the chemistry of the ancestors of the genus, and now to a limited extent on climatic environment rather than on escape from enemies. In some exotic species the colour has not been perfectly developed. The North American *E. gapperi* is sometimes dichromatic, having a phase in which the rufous are replaced by sooty tints (G. S. Miller, *Proc. Boston Soc. Nat. Hist.*, April 1897, 16). *E. proteus*, Bangs, of Labrador, shows wide colour-variation, the back varying from mouse-brown to bright rufous (Outram Bangs, *Proc. Biol. Soc. Wash.*, xi., pl. iv., 17th September 1897, 239). Some forms are very brown, *e.g.*, Thomas's *E. frater* of Thian-Shan. *E. smithii* of Japan has the young dark slate-coloured.

[3] In Norway; Robert Collett.

[4] William Borrer, *Zoologist*, 1887, 462.

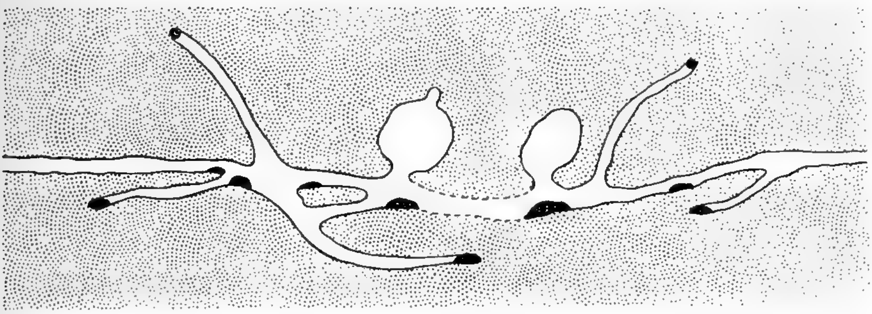
[5] *Natural History and Sport in Moray*, ed. 1882, 257.

[6] The specimens from which J. C. D. von Schreber described his *glareolus* were caught amongst beds of sea grass (*Elymus*). In similar situations on Bering Island, Kamchatka, *E. wosnessenskii* accompanies the grass to its seaward limit, and in such localities L. Stejneger and I sometimes found it very plentiful.

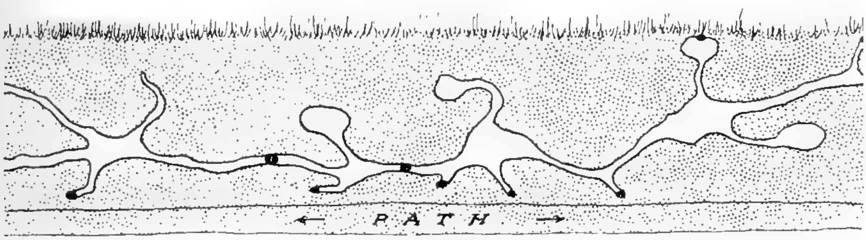


BRITISH *Microtinæ* (SKINS);
(1, 2) *Arvicola amphibia amphibia*; (3) *A. a. reta*; (4, 5) *Evotomys glareolus*; (6, 7) *E. skomerensis.*

Although it is often content to dispense with the "runs" which are so characteristic of the more sedentary Grass Mouse, a colony in permanent occupation of a bank or hedgerow usually constructs a complicated series of shallow galleries, partially below the ground. These have been carefully excavated by Mr L. E. Adams, who has supplied me with several plans of them (Fig. 64). They are of irregular construction and diameter,



(1)



(2)

FIG. 64.—DIAGRAMS OF (1) BURROWS OF BANK MOUSE; (2) A GENERAL MURINE HIGHWAY IN A HEDGEROW, probably constructed in the first instance by Bank Mice. The black spots indicate the entrances to the burrow. (From plans and sketches supplied by L. E. Adams.)

with numerous openings, blind terminals, and enlarged chambers, which may extend for a considerable distance along a bank. There is generally a more or less central highway, which is used by all wandering mice or shrews in common. That intercommunication is the sole or main object of the runs examined by Mr Adams seems to be proved by the entire absence from them of nests, traces of food, or other signs of occupation. It may be that in a southern county like Surrey

the mice sleep without regular couches wherever they may happen to be overtaken by drowsiness, but in more northern localities they certainly construct dormitories and accumulate food-stores,[1] especially in winter. It seems likely that the highways are a special feature connected with southern agriculture and enclosed fields, and in such extensive burrows a variety of antagonistic species might pass to and fro in safety, concealed from each other by the darkness and absence of distinct "scent."[2]

This is a bold species, not timorous of observation by man, and devoid of suspicion of traps, which, as for the Common Shrew, are most successful when most conspicuous. Almost any bait, from nuts to meat, is efficacious. If a mouse be seen running along a hedgerow, and a trap be then set, a capture may frequently be effected within a short time.[3]

Though fond of green stuff, the Bank Mouse perhaps more frequently[4] consumes roots, kernels, nuts, fruits, berries, grain or seeds.[5] Its love for bulbs, carnations, peas, and roots makes it a pest in gardens. In spring it ascends the shrubs of the hedgerow to nibble away the tender leaves,[6] and in autumn climbs for hips and haws. These are frequently carried off to a burrow and eaten at the entrance, or to a disused bird's nest, where a heap of rejectamenta betrays the feasts.[7] Both the kernels and flesh of hips may be eaten, and a hole is rapidly cut through the shell of a filbert or hazel nut, through which the contents are extracted. The shell is pierced in about a minute; the kernel extracted in about an equal time. Gooseberries are treated like nuts, being neatly emptied of their contents by a hole in the side.[8] Apart, however, from the necessary boring of a hole, it (like other mice) differs from

[1] See below, p. 436. [2] *Cf.* above, article *Rabbit*, p. 205.

[3] The first two specimens of *E. cæsarius* of Jersey were thus taken by me, traps being placed where the mice were seen running about at 11 A.M., and taken up before dark. Borrer (*op. cit.*) once had a wild Bank Mouse sitting on his foot.

[4] As is shown by the fact that in captivity it will not survive long without hard food (A. H. Cocks).

[5] In Norway an *Evotomys* was caught hurrying off with seven grains of barley in its mouth (Collett). [6] Especially of wild rose and hawthorn: see W. Evans; F. Coburn, *Zoologist*, 1894, 303. [7] J. H. Teesdale, *Journ. cit.*, 1895, 186. Cocks reports (January 1914) a blackbird's nest in a hedge quite full of nibbled hips.

[8] Alston, *Zoologist*, 1866, 9-10.

the Dormouse in having no regular plan of attack. Mr English has observed that when carrying a nut to its burrow or store it uses the three methods in use amongst rats: it either seizes the pointed end between the teeth and jumps along with head high in the air, or it wedges the burden between the chin and fore legs, or rolls it along the ground.

The Bank Mouse sometimes causes damage to young plantations, but this seems to occur chiefly in Scotland;[1] climbing the trees, it eats out the buds, especially of larch, and devours the bark to the end of the branches, which, if very small, are first gnawed off and allowed to drop.

Sometimes in its climbing expeditions it accidentally meets with booty in young birds,[2] and it is stated to be fond of many kinds of insects, and of molluscs.[3] Lastly, it is an inveterate cannibal, and in captivity has been known to kill and devour the reputedly unpalatable Common Shrew.[4] It may thus be described as omnivorous and cannibalistic in contrast to the almost entirely vegetarian, though also cannibalistic, Grass Mouse.[5] Its diet is well shown by the ordinary contents of its stomach, a yellow substance "like pease-pudding," in contrast to the chewed grass to be found in those of entirely vegetarian species.[6]

In feeding, it either holds its food down with its fore paws, or sits upright and handles it like a Dormouse. When devouring the carcase of a fellow-mouse, although it never eats the skin, it does not invert it as would a shrew; it merely turns back as much of the skin as is necessary to get at the brain and thorax, after which the carcase usually receives no more attention.[7]

[1] First reported by Rev. G. Gordon (*Zoologist*, 1844, 425), who later sent specimens to Alston (in Bell) from Morayshire; also mentioned by Service (*Solway*, 206); H. S. Gladstone for Dumfriesshire; Robert Thompson (*Nat. Hist. of a Highland Parish*, 82, 1900) for Nairnshire; and William Taylor for Llanbryde, near Elgin. Similarly in Norway, according to Collett, attacks are most conspicuous in the north, possibly as a result of scarcity of food on the ground.

[2] Victor Fatio.

[3] E.g. *Helix nemoralis*, and *H. aspersa;* C. Wright, per Adams.

[4] Alston, in Bell.

[5] The facts are well put by R. I. Pocock, *Zoologist*, 1897, 507.

[6] W. E. de Winton, in R. Lydekker.

[7] Adams, *MS.*

Occasionally it enters houses, and robs cupboards[1] and gardeners' stores;[2] but this does not seem to happen so often in the British Islands as in more northern countries—as in Norway, where in winter the habits of the local Bank Mice resemble those of the House Mice, which they accompany to the very roof.[3] In Norway also it accumulates stores of provisions. As stated above, the latter habit does not seem to be universal in this country, but Mr English once excavated five Bank Mice, and ninety-three cob-nuts, the latter all intact, and tightly packed together. In Britain it sometimes obtains both food and shelter by constructing a winter nest of short dry straw or grass in swede or potato clamps.[4]

It is a hardy mouse, and is not confined to its retreat in times of frost or snow.[5] Mr Adams found it the only species coming to traps at a temperature of 14° Fahrenheit.

The period of gestation was ascertained by Mr Robert Drane to be twenty-eight days, in a captive female which produced a second litter that number of days after isolation with a previous one.[6]

The young, which at birth are about as advanced in development as those of other mice,[7] are born during a long sexual season, which in the south of England lasts regularly

[1] One caught in a cupboard at Vaynol Old Hall, Bangor, N. Wales, in September 1904, was forwarded to me by H. E. Forrest; Dalgliesh has also sent me a similar note; and see also Rope, *Zoologist*, 1898, 503.

[2] J. Sutton, *Journ. cit.*, 1888, 23.

[3] In the Yukon region W. H. Osgood found *E. dawsoni* always about log-cabins (*North Amer. Fauna*, No. 19, 1900, 34). In Kamchatka *E. wosnessenskii* frequents dwellings and accumulates stores of food often carried from quite a distance; thus sheltered, it rears young throughout the year, but on the tundra is inactive in winter; N. G. Buxton, in J. A. Allen, *Bull. Amer. Mus. Nat. Hist.*, 31st March 1903, 147-8.

[4] G. Roberts, *Zoologist*, 1866, 206; H. A. Macpherson, *Journ. cit.*, 1894, 149, and *Lakeland.*

[5] R. J. Cunninghame took specimens (British Museum) of the Norwegian *E. glareolus suecicus* in January and February, on two or more feet of snow, in cold weather; and in that country *Evotomys* tunnels under the snow (Collett). More probably it objects rather to wet than to cold weather. In this connection it may be well to contrast the shrews, whose voracious appetite and rapid digestion compel activity in all weathers to avoid starvation, with the mice, which, although large eaters, have a slower digestion, and can exist much longer without food.

[6] Thus confirming F. Lataste's "law"; see above, p. 375; had she not been nursing, the young would presumably have been born on or about the 21st day.

[7] Lataste, 382.

from March to December inclusive, and probably includes also not infrequently January and February. Mr Adams gives the average of twenty litters as 3·8 young; he has examined in all 2 of six, 6 of five, 15 of four, 13 of three, and 2 of two. Very probably these figures include the litters of young mothers, and of unfavourable seasons. A series examined in the height of the sexual season should give larger results, and Mr Cocks reports a litter of eight found on 27th May 1911.

The nurseries may be found, usually above ground, in hedgerows or hayfields. They are composed of grass, the interior bitten fine,[1] and a lining of moss, sheep's wool, or feathers[2] may be added; thus serving to distinguish the structure from that of the Grass Mouse, which only uses such luxurious materials in winter. Collett mentions a Norwegian nest which was placed on the roof of a house at a height of nearly 20 ft.; another was built into that of a Fieldfare, at 6 ft. from the ground, in a young spruce; it was domed, with a small entrance near the under side.

According to observations made on captives, young were observed with the eyes open on the fifth day from birth, at which time they were clothed with blackish down, and their whiskers began to show; on the seventh day they were brownish.[3] The members of another litter[4] began to move about when eleven days old, and at fourteen days were fully furred, active, and able to feed themselves.

Bank Mice have frequently been kept in captivity, and evidently vary much in individual disposition, being sometimes described as inoffensive and amiable, at others as shy, irreconcilable, and easily provoked to bite. Macpherson, for instance, had two, of which one was sullen and untamable; the other, which had a charming temperament, was eventually murdered and eaten by its companion. They are fond of preening their fur. They sleep with the head tucked away under the belly between the fore paws, and sometimes make a

[1] English's captives cut stiff hay into lengths of 1 inch or less, which then gained breadth by splitting of themselves longitudinally.

[2] Fatio.

[3] English; the first date is so very early, that an error may be suspected, and it would be desirable to have confirmation of any date earlier than the eleventh day.

[4] T. V. Roberts, *Zoologist*, 1892, 329; see also *Nature Notes*, 1903, 130.

"form" for themselves like a hare. Several observers have found that they appreciate the well-known "wheel," which forms a regular appendage to cages for mice.

Any excitement such as fighting or pairing is accompanied by much squeaking, the voice being comparatively deep-toned, "a short, grunting squeak," neither so sharp nor so prolonged as that of the Field Mouse or House Mouse.[1] One in the possession of Mr F. Norgate[2] fought and squeaked at him when he robbed it of a laburnum seed. The mother of Mr T. V. Roberts's litter was most jealous of her young being seen, and freely carried them about in her mouth, or, when they grew older, drove them into their sleeping compartment. The mother of Mr English's attacked him in defence of her young, and died when caught.[3]

Bank Mice are quarrelsome to their own species, and in fighting make a great fuss; grinding their teeth, they stand upright on their hind legs, and hop round each other, stretching out their fore paws for protection, or bending backwards to avoid attacks.[4]

This mouse is not usually associated with "mouse plagues," but Collett mentions several in Norway, chiefly in the north of the country. When food is abundant the numbers increase proportionately, and Mr Cocks noticed that the exceptional beech-mast harvest of 1900 resulted in great swarms of this species and of the Field Mouse at Poynetts, Buckinghamshire; the normal numbers were not resumed until the following summer. Mr J. G. Millais[5] and Mr de Winton[6] attribute the devastation of the Forest of Dean, Gloucester, in 1813-1814, to Bank Mice. Except the fact that woods, and not pastures, were destroyed, and Edward Jesse's description[7] of the "short-tailed mouse" concerned as having the upper parts "of a reddish brown," there is no evidence in support of this sup-

[1] Rope, *op. cit.* The pairing shriek is "un cri aigu et chevrotant, qui rappelle celui de la Fauvette" (Lataste, 382); Collett states that when two meet (in Norway) they frequently utter a loud "tyee-tyew-tyew-tyee," the syllables repeated in rapid succession.

[2] *Zoologist*, 1874, 4236.

[3] For accounts of captive Bank Mice, see Rev. H. H. Slater, *Zoologist*, 1887, 462; E. R. Alston, Rope, Head (very tame), T. V. Roberts, *opp. cit.*; and Macpherson, *Zoologist*, 1894, 149.

[4] Rope. [5] ii., 247. [6] In Lydekker.

[7] *Gleanings in Natural History*, 6th ed., 1845, 111-114.

position. The tint mentioned would quite well describe the Grass Mouse, which is ready enough to attack woods in times of superabundance. It is, however, most probable that Bank Mice are often present amongst the hordes of Grass Mice in "mouse-years." Great numbers of mice were reported from woods at Faldonside, Berwickshire, in the winter of 1882-1883, and a specimen sent to Mr James Hardy[1] for identification proved to be of the present species. In 1888 the Bank Mouse was very abundant in Leigh Woods, Bristol District, having been seen in small scattered parties of eight or ten travelling steadily down the valleys.[2]

There are few records of the longevity of this mouse, the maximum duration in the Zoological Society's Gardens having been fourteen months.

THE SKOMER BANK MOUSE, OR DRANE'S MOUSE.

EVOTOMYS SKOMERENSIS, Barrett-Hamilton.

1903. EVOTOMYS SKOMERENSIS, G. E. H. Barrett-Hamilton, *Proc. Roy. Irish Acad.*, 11th May, 316; described from Skomer Island, Wales (type specimen, No. 3.7.4.3 of British Museum collection); Trouessart; Miller; Pycraft, British Museum, *Guide to British Vertebrates*.

1903. EVOTOMYS SCOMERENSIS, R. Lydekker, *Zoological Record, Mammals*, 34 (misprint).

1905. EVOTOMYS HERCYNICUS SKOMERENSIS, J. G. Millais, *Mammals of Great Britain and Ireland*, ii., 250.

Distribution:—This mouse is only known from Skomer Island, off the coast of Pembrokeshire, Wales.

Description:—It differs from the Common Bank Mouse in its larger size; in the exceptionally light and bright colour of the upper side, which is in sharp contrast to the buffy white under-side; in its large, massive skull, and in the complicated form of m^3.

In late winter or spring the mantle is broad, encroaching considerably on the paler sides; its general **colour** is between "orange rufous," bright "cinnamon rufous," and "madder brown." On the face, sides of the head, and flanks the bright rufous tints are less conspicuous, running through light "hazel" or "vinaceous cinnamon" to a dull "greyish buff." The rump and the upper side of the sharply bicoloured tail are "mummy brown." The under-side of the body and tail, with the legs and feet, are whitish, usually with a very perceptible wash of yellowish on the belly.

The large, unusually ridged and angular **skull** needs no comparison

[1] *Proc. Berwickshire Nat. Club*, x., ii., 278, 1885. [2] H. J. Charbonnier.

with that of *E. g. britannicus.* From those of *E. nageri nageri* and *E. n. norvegicus* (see next page), which agree with it in size, it differs in its great relative depth, in the short, broad, rather strongly ridged and angled brain-case, conspicuous mastoid region, and unusually elongate, centrally contracted almost spatulate nasals, which are decidedly longer than the diastema. The post-orbital processes of the squamosals are small, but unusually well defined, and send well-developed ridges backwards and upwards nearly to the anterior edges of the parietals.

The **cheek-teeth** are large, and similar to those of *nageri*, m^3 having normally three infolds on the inner side (Fig. 63).

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).
1. Male, 7th April 1900 (No. 3.7.4.3 of British Museum collection), Y. H. Mills (type of species) . . .	108	59	18	13
2. Seven males and five females—				
Minimum	105	50	17	12
Average	109 5	55·5	18	13·5
Maximum	114	61	19	15
3. One mentioned by Miller . . .	121	..	..	..

Skull:—Condylo-basal length, 24·8 to 25·8; breadth at zygomata 14·2 to 15; at inter-orbital constriction, 4 to 4·2; at occiput, 12 to 12·6; median occipital depth, 6·4 to 7·0; greatest length of nasals, 7·6 to 8·2; of diastema, 6·8 to 7·2; of mandible, 15·6 to 16·4; of maxillary tooth-row, 5·6 to 6; of mandibular tooth-row, 5·4 to 5·8.

History:—Specimens of this mouse were taken by Drane at Skomer Island in June 1897. He saw at once that his captures differed from *glareolus*, being much larger and having distinct teeth ("A Pilgrimage to Golgotha," in *Rep. and Trans. Cardiff Nat. Soc.*, xxxi., 1898-99, 46, 1900). In an account read 15th Dec. 1898 (*Trans. cit.*, xxxiii., 1900-1901, published 1902), of a second visit to Skomer Island in June 1898, Drane added that he felt inclined to regard his mice as representing "a hitherto unnoticed variety." He took every trouble to get his specimens correctly named, and for that purpose he submitted them, both living and dead, to the Linnean Society of London (*Proc.*, June 1899, 63), and to the authorities of the British Museum; but so great was the lack of knowledge at that date that he received no more satisfactory answer than vague suggestions about a "local variety of *glareolus*."

In 1898 I became aware of the existence of the Skomer Bank Mouse. In October of that year Marsden sent me two taken by Mills, to which Mills afterwards added ten more. These remained in my collection until the publication in 1900 of Miller's "Preliminary Revision of the European Red-backed Mice" (*Proc. Wash. Acad. Sci.*, 26th July 1900, 83-109). This suggested a re-examination of the Skomer specimens, with the result that in 1906 I described the new British Mammal and definitely assigned it a place amongst other related forms of neighbouring countries. It is clear that to Drane belongs the honour of discovering this species (see Proger, *Field*, 20th Feb. 1904, 321; Thomas, *Field*, 12th March 1904, 451), but, that, without Miller's paper, Drane's discovery was meaningless and its value could not be recognised.

Status:—*E. skomerensis* belongs to a group of European bank mice, characterised by size larger than that of *glareolus*, and distributed in isolated colonies, on mountains or islands. These are comparable to the two continental forms of *Lepus timidus*, and may logically be treated as sub-species of one central form, *E. nageri* (Schinz, 1845). The meaning of this group is shown by Hinton's determination of a closely allied form or forms from the late Pleistocene of Ightham, Kent; Brixham, Devonshire; and St Lawrence, Isle of Wight. This palæontological evidence and the characters of *skomerensis* indicate that the latter is a somewhat modified survivor from an older fauna, which has been everywhere driven out by the newer and more recent arrival, *glareolus;* the remains of this last occur for the first time in Britain in the Pleistocene of Ightham, alongside those of the then existing member of the older group. The reality of the group is not invalidated by the fact that one of its forms, *E. nageri*, intergrades with *E. glareolus* through the sub-species *E. n. helveticus*. The large and small forms still remain distinct in origin. As in the case of *Lepus*, isolated members of the group have become so far differentiated as to have attained specific rank; and indeed it is only a matter of convenience whether such geographically isolated forms as *norvegicus* and *nageri* be given the superior or the inferior grade. The following are the known forms, excluding *E. alstoni* and *E. erica* of Scotland, described below:—

E. nageri norvegicus (Miller) of western Norway, and north at least to Nordland, has a broad mantle not sharply defined from the buffy-grey flanks, the hind foot 18·4 to 19, a heavily built skull, the condylo-basal length of which is 24·2 to 26·2 mm., and m^3 has usually three internal infolds. *E. n. vasconiæ* (Miller), of the French side of the Pyrenees, is very similar to the last, but perhaps larger, and with a duller, narrower mantle and less buffy sides. *E. n. nageri* (Schinz) of the Alps and the northern Italian mountains, is slightly larger than *E. n. norvegicus* (hind foot, 18·8 to 20; condylo-basal length of skull,

25 to 26·2 mm.), and has a narrow dark mantle moderately in contrast with the dull greyish flanks. *E. n. hallucalis* (Thomas), of the Aspromonte Mountains and Monte Pellino, southern Italy (Basilicata and Calabria), is a well-marked form, closely resembling *E. n. nageri* externally, but with a longer, narrower brain-case, shorter rostrum, short wide incisive foramina, and larger teeth. Miller's *E. cæsarius* (*Ann. and Mag. Nat. Hist.*, February 1908, 194), first taken by me at St Helier, Jersey, has rich dark colour, short tail and ears, and very large and massive skull; the head and body averages 111, tail 51, hind foot 19·3, ear 11·4, and condylo-basal length of skull 25 to 27·4.

Origin:—There can be no doubt that the Skomer Mouse is the descendant of ancestors formerly inhabiting a region extending at least from Raasay Island, Scotland, to Skomer Island and Jersey. As stated above, they have been driven out by *glareolus*, and isolation has produced local differentiation, so that there are now four known forms, of which *skomerensis* and *cæsarius* are more distinct than the representatives of the same stock inhabiting the mountainous regions of western Europe. The recent discovery of the Scottish members of the group remarkably fulfils Stejneger's prophecy (*Smiths. Misc. Coll.*, 4th May 1907, 478) that he "would not be surprised if they also were to be found in the northern highland of Scotland."

Very little is known about the **habits** of this mouse. Mr Robert Drane always took it about or inside farm buildings, and Dr Y. H. Mills in the heaps of swedes in which it was feeding. Mr Drane kept five alive, and these soon became tame, and increased to forty-seven between June and October. He mentions a litter of five.

ALSTON'S BANK MOUSE.

EVOTOMYS ALSTONI, Barrett-Hamilton and Hinton.

1913. EVOTOMYS ALSTONI, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Abstract Proc. Zool. Soc.* (London), No. 119, 15th April 1913, 18; and *Proc. Soc. cit.*, 1913, 827; described from Mull, Scotland (type specimen No. 14.1.30.4 of British Museum collection).

Distribution:—This mouse is at present known only from the Island of Mull, Scotland, where five specimens were taken by R. W. Sheppard in June 1912, during a trip managed by Ogilvie-Grant and financed by many subscribers.[1]

[1] This first attempt at systematic examination of the mammals of the western islands of Scotland, carried on, in spite of many difficulties, under the superintendence of Ogilvie-Grant, by R. W. Sheppard in 1912, and by D. Anderson, P. D. Montague, and C. H. B. Grant in 1913, resulted in the discovery of one new species of Shrew (*Sorex grantii*), two new species of Evotomys (*E. alstoni* and *erica*); and three new sub-species of the Northern Grass-Mouse, *Microtus agrestis*

Description:—It is a quite distinct form of comparatively large size, but with relatively short ears and tail, and peculiar skull.

In general **size** it approaches *norvegicus*, being larger than *glareolus* but smaller than *skomerensis*. The tail and ears are about as in *glareolus*, the hind feet about as in *norvegicus* or *skomerensis*.

The **colour** is similar to that of adults of the deeply-tinted forms of *glareolus*, being deep "russet" above, the under-side richly washed with yellowish or buffy tints.

The **skull** is larger than in *glareolus*, and agrees in size with that of *norvegicus*, as it does also in the heavy jugals, although the curvature of the zygomata is similar to that of *glareolus*. The brain-case is very broad and smoothly convex, the temporal ridges being but faintly indicated even in aged skulls, and the parietal region in dorsal profile is not flattened but convex, with the highest point a little behind the middle of the parietals; these features impart an appearance of relatively greater cranial capacity than is seen in any other European species of *Evotomys*. The squamosal post-orbital processes are not conspicuous. The inter-orbital region is broad, with a wide shallow median sulcus. The nasals are rounded or slightly and narrowly emarginate behind; they end flush with or slightly behind the ends of the premaxillaries, and are slightly longer than the diastema; they are

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).
1. Male, aged, Mull, Scotland (R. W. Sheppard), 18th June 1912 (type)	108	44	18	11
2. Male, ditto	110	44	19·5	11·5
3. Male, ditto, 19th June 1912	103	44	18	11
4. Female, ditto, 13th June 1912	105	45	18·5	11·5
5. Female, ditto, 14th June 1912	100	42	18	10
Average of five adult specimens of both sexes	105·2	43·8	18·4	11

macgillivraii, *M. a. mial*, and *M. a. luch*); in all, of six new forms. The work resulted in very material additions to our knowledge of the distribution of British mammals, and, in particular, of the relationships and classifications of the difficult sub-family of *Microtinæ*, and has thrown much light on the origin of the recent British fauna. The collections made included 280 specimens of 11 species, and have been described by myself and Hinton in *Proc. Zool. Soc.* (London), 1913, 821; and *Ann. Mag. Nat. Hist.*, October 1913, 361; a further paper is in contemplation.

It may safely be said that no collection of British mammals has ever approached the present one in importance.

expanded in front, with their lateral borders slightly but distinctly concave. The rostrum is shallow, as in *E. norvegicus*, its least depth behind the incisors not exceeding its anterior width. The auditory bullæ are about as in *norvegicus*. m^3 has a third inner infold and a fourth inner salient angle, the latter usually well developed.

Skull:—Length, condylo-basal, 24·1 to 25·3; of nasals, 6·8 to 7·8; of diastema, 6·3 to 7·7; of mandible, 15·1 to 15·7; of maxillary tooth-row, 5·2 to 5·7; of mandibular tooth-row, 5·1 to 5·4; breadth, zygomatic, 13·5 to 14·5; inter-orbital, 3·8 to 4·1; occipital, 11·4 to 12·1; depth, median occipital, 6·0 to 6·6.

Status:—Alston's Bank Mouse is, like *E. skomerensis*, probably a relict of an ancestral form of large size which occupied Britain before the arrival of *glareolus*. Being allied to *E. nageri norvegicus* of Skandinavia, it is the latest link in the chain connecting the mammals of Scotland and Skandinavia, and its existence is apparently another indication of a comparatively recent land-connection between the two countries.

THE RAASAY BANK MOUSE.

EVOTOMYS ERICA, Barrett-Hamilton and Hinton.

1913. EVOTOMYS ERICA, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, October 1913, 361; described from Raasay, near Skye, Scotland; type specimen, No. 14.1.30.5 of British Museum collection.

Distribution and History:—This mouse was discovered on the island of Raasay in April 1913 by Montague (see footnote, p. 422 *supra*), who found it rather scarce; his three specimens were "trapped in big heather."

Description: — It resembles *E. alstoni* in general appearance and colour, but is slightly larger, has a more robust tail, and the ventral surface much more heavily washed with buff, in sharp contrast with the dark brown of the flanks and upper surface of the tail.

The **skull** is distinguished from that of *E. alstoni* by its much larger cheek-teeth, broader zygomatic arches, heavier jugals, more salient and extensive post-orbital crests, flatter parietals, narrower inter-pterygoid space, wider pterygoid fossæ, vertical instead of ventrally divergent pterygoids, and auditory bullæ with their antero-internal parts produced inwards as blunt points instead of being rounded. The mandible differs principally in its larger size, and in having the lower borders of the angular processes widened into broad surfaces for the insertion of the superficial parts of the masseter muscles: the width of these muscular facets is 1·4 mm. as against 0·4 mm. in *E. alstoni*.

The **teeth** are of normal form, differing from those of *alstoni*

merely in their larger size. As in the latter species, m^3 has a deep third inner fold, and usually a large salient fourth inner angle.

Dimensions in millimetres:—Collector's measurements of three adult but not old males: head and body, 110 (type), 112, 114; tail, 45, 48, 50; hind foot, 18, 20, 20; ear, 13, 14·5, 14.

Skull:—(two males, Nos. 79 (type) and 81), condylo-basal length, 25·2, 25·4; breadth, zygomatic, 14·7, 15; least inter-orbital, 3·7, 3·8; mastoid, 11·8, 11·9; occipital depth, 6·4, 6·6; length of nasals, 7·1, 7·4; of diastema, 6·7, 6·7; of maxillary tooth-row, 6·2, 6·3; of mandible, 16·1, 16·4; of mandibular tooth-row, 6·1, 6·1.

Status:—Like its near relative, *E. alstoni*, the Raasay Bank Mouse seems to be another member of the so-called "Boreal" group of species, surviving in an island, because of the immunity from competition which it there enjoys. Unlike *E. alstoni*, but in this respect resembling *skomerensis* and *cæsarius*, it has undergone considerable specialisation, apparently to fit it for subsistence upon a coarser, and probably a more exclusively vegetarian, diet. It has developed relatively large cheek-teeth, requiring more powerful muscles to move the jaws. The strengthening of the muscles has, in turn, caused those parts of the skull and mandible to which they are attached to grow stronger, and in this way the many differential characters of the skull noted above appear to have been brought into existence. The muscles affected by the enlargement of the teeth are the temporals, masseters, and pterygoids, and every one of the cranial features described is correlated with the increased development of one or other of them.

Genus Microtus.

This genus includes the typical Microtines, which generally but not invariably differ from the members of the genus *Evotomys* in their shorter ears and tail, and in the dull brownish tints of their dorsal surface.

They are first known from the late **Pliocene** of Europe, three or four species having been described from the British Upper Freshwater Bed of Cromer. They appear also in the early Pleistocene of Greenhithe, Kent (Hinton), and in most deposits of later dates, as at Grays Thurrock (*M. agrestoides*, Hinton, *Proc. Geol. Assoc.*, 3rd June 1910, 493, a form characterised by the presence of a fourth exterior angle in m^3), and Ilford, Essex. Some of the early species appear to belong to the sub-genus *Chionomys*. In North America the genus is not known earlier than the Pleistocene.

Although still imperfectly known, the genus includes a bewildering number of species, which, with their sub-species, probably outnumber all other members of the sub-family united. These are widely **distributed** in boreal and transitional, less frequently in arctic or subtropical zones, from ocean to ocean in North America, with Newfoundland, and south to southern Mexico; in Eurasia from the Outer Hebrides to Kamchatka; and south to Portugal, Central Spain, the Mediterranean coasts of France, Northern Italy, the central portions of the Balkan Peninsula, Asia Minor, Northern India, and the island of Kiushiu, Japan.

The genus probably **originated** in Asia and crossed to North America by the Bering Sea route, leaving traces of its presence in St Lawrence (*M. innuitus* of Merriam); St Matthew and Hall Islands, Bering Sea (*M. abbreviatus* of Miller).

The genus having been subdivided, its **characters** may be given under the sub-genera.

Sub-Genus MICROTUS.

1798. *Microtus*, F. v. P. Schrank, *Fauna Boica*, 1, 72, based on *Microtus terrestris* of Schrank=*Mus arvalis* of Pallas; Lataste, *Le Naturaliste*, 15th October 1883, 348 (sub-genus); Miller, *N. Amer. Fauna*, No. xii., 23rd July 1896, 62; and *Catalogue*, 1912.

Synonymy:—Owing to difficulties of identification and classification, the synonymy is long and complicated; but, since the segregation of the Water Rats in the genus *Arvicola*, a name formerly used to include all "voles," there can be no doubt as to the use of the name *Microtus* for the present genus. The full synonymy may be found in Miller's *Catalogue*.

These mice are sedentary grass-feeders of much narrower habits than the Bank Mice. They are neither climbers nor specially modified for a subterranean existence, in either fur, which is never dense or mole-like, or claws, which are slightly larger on the hind feet. The soles are moderately hairy, and there are six plantar pads, of which one may be rudimentary.

The **mammæ** are eight, as in *Evotomys*.

The **skull** is ridged and angular; the inter-orbital region narrow; the temporal ridges well developed. The bony palate (Fig. 60, B, p. 401) terminates posteriorly in a median ridge

sloping dorsally between two lateral pits; this ridge becomes narrower and more abrupt with age; it may sometimes encroach on the anterior edge of the inter-pterygoid fossa, or it may be slightly cleft centrally.

In the **teeth** the root of each lower incisor crosses the tooth-row to the labial side between m_2 and m_3, displacing the latter tooth and forming a more or less distinct protuberance on the outer surface of the condylar process of the mandible.

The cheek-teeth are permanently rootless; growing continuously from a persistent pulp, they do not wear away with age. Their enamel-pattern is characterised by the substantial closure of all triangles in adult stages of wear, by acute salient angles, and by the large number of salient angles in m^3 and m_1. m^3 usually consists of an anterior transverse loop succeeded by three closed triangles, two smaller on the outer and a larger on the inner side, followed by a posterior loop of variable shape. There are at least seven salient angles (four on the inner side), two formed by the anterior transverse loop, one by each of the three closed triangular spaces, and two by the posterior loop.

In m_1 there are usually a posterior transverse loop; five closed triangles—two on the outer and three on the inner side; and an anterior loop, usually more or less deeply cut by an inner and an outer fold, the latter always posterior to the former. There are in normal species seven infolds and at least nine salient angles; two of the latter are formed by the posterior transverse loop, one by each of the five closed triangles, and one by each side of the base of the anterior loop.

Variations from the normal enamel-pattern of the genus occur constantly, and characterise the dentition of several species; in addition there may exist in any species variations of a purely individual nature, often due to varying stages of tooth-wear. In m^3 the first outer triangle may open into the large inner, or less frequently into the anterior loop. The second outer triangle may rarely open into the inner, but rather frequently communicates with the posterior loop. The posterior loop is of quite variable shape. In m_1 there may be a sixth, occasionally a seventh, closed triangle, in each case cut off from a much reduced anterior loop. Sometimes the fourth

inner fold (counting from behind) fails to meet the third outer; or the anterior loop is complicated by the development of one or more additional salient angles and infolds on either side anteriorly.

The British species and sub-species are as given below. They fall into two groups:—

1. *Agrestis* group.
   (1) *M. agrestis macgillivraii*, of Islay.
   (2) *M. agrestis exsul*, of the Outer and Inner Hebrides.
   (3) *M. agrestis mial*, of Eigg.
   (4) *M. agrestis neglectus*, of the Scottish Highlands.
   (5) *M. agrestis luch*, of Muck.
   (6) *M. hirtus hirtus*, of Britain south of the Highlands.

2. *Orcadensis* group.
   (7) *M. orcadensis ronaldshaiensis*, of South Ronaldshay.
   (8) *M. orcadensis orcadensis*, of Pomona.
   (9) *M. orcadensis rousaiensis*, of Rousay.
   (10) *M. orcadensis westræ*, of Westray.
   (11) *M. orcadensis sandayensis*, of Sanday.

Much new material has been received only since the publication of the earlier pages on *Microtinæ*, and therefore two sub-species of *agrestis*—*mial* and *luch*—and two of *orcadensis*—*ronaldshaiensis* and *rousaiensis*—could not be included in the Key to the *Muridæ* on pp. 377-381.

Group AGRESTIS.

Miller grades all the west European Grass Mice having an extra prism in m^2 as sub-species of *agrestis*. This method, however, obscures their relationships, especially the fact that, as in *Evotomys*, a newer, smaller form, *M. hirtus*, has replaced an older, larger, *M. agrestis*, the latter now confined chiefly to northern regions, and with isolated southern colonies on mountains. These two forms are of entirely distinct origin, and are here given specific rank, and each has sub-species. Like *Lepus timidus*, *Evotomys skomerensis*, *alstoni*, and *erica*, *M. agrestis* belongs to an older fauna; *M. hirtus* to that of *Lepus* (*Eulagos*) *europæus* and *Evotomys glareolus*.

This division of Linnæus's *agrestis* into two forms has long been known, as to de Sélys in 1841. Although its meaning was not recognised, it was discussed by Blasius in 1857, and by myself in 1896. The scanty material available, and the lack of knowledge of the synonymy, structure, and geological history of the various forms long militated against a satisfactory use of the facts.

The *agrestis* group ranges right across northern Asia, at least to North-western Mongolia (*M. a. mongol* of Thomas) and Dzungaria (*M. arcturus* of Thomas).

In America it is represented by several allied but distinct forms which occupy the whole continent in subarctic, boreal and transitional zones, from Alaska to Labrador and Newfoundland.

The group is thus quite comparable to others of circumpolar distribution. As it avoids the extreme north, it has no species common to the Old and New Worlds. *M. pennsylvanicus* (Ord) of the eastern United States is so closely allied to *M. agrestis* in skull and teeth, that it has been used as an argument for a recent Atlantic land-bridge (Scharff); but it is quite distinct in colour in a group where all the forms are closely allied.

THE NORTHERN GRASS MOUSE.

MICROTUS AGRESTIS (Linnæus).

1761. MUS AGRESTIS (species), Carolus Linnæus, ***Fauna Suecica***, ed. ii., 11, No. 30; described from Upsala, Sweden (from the ***Mus agrestis minor*** of Gesner).

1766. MUS GREGARIUS (species), Carolus Linnæus, *Systema Naturæ*, xii., 84; described from Germany and Sweden.

1857. ARVICOLA AGRESTIS (a.), J. H. Blasius, *Säugethiere Deutschlands*, 369 (part).

Markmus of the Norwegians; not known to the French or Germans.

This abbreviated **synonymy** is that of the species *agrestis*, the technical name of which admits of no doubt; since the typical subspecies is not found in Britain, there is no need for detail, which may be found in Miller's *Catalogue*. That of the five British sub-species is given at length under each. As in the case of other animals (*e.g.*, bats, shrews, and hares), there was formerly some doubt as to the identity of *agrestis*, owing to the presence of a second species, *arvalis*, which, although abundant in many parts of Europe, is not known in Skandinavia.

Distribution:—The Northern Grass Mouse ranges from the Outer Hebrides, Scotland, and Skandinavia, at least to North-western Mongolia, where the local form, *M. a. mongol* of Thomas, can only be distinguished from true *agrestis* by its larger bullæ; there is also an isolated colony—*M. a. levernedii* (Crespon)—inhabiting the Alps, Jura, and neighbouring portions of Switzerland and France, with the marshes at the mouth of the Rhone on the Mediterranean coast of France. Although completely isolated geographically, *levernedii* is not well differentiated from *M. a. agrestis* of Skandinavia, and can only be distinguished by its longer and narrower skull, in which the distance from the condyles to the back of the inter-orbital constriction is usually greater than the zygomatic breadth, whereas in *M. a. agrestis* these two dimensions are usually about equal. *M. a. agrestis* is, in Skandinavia, chiefly, but not entirely, a lowland form; it is one of the most numerous mammals of Norway, being found on the cultivated islands and ranging to the extreme north of the country at Lebesby (Collett).

In **Britain** it is confined to the Highlands of Scotland and the western Scottish islands (but notably absent from Lewis), where it occurs in five sub-specific forms.

Distribution in time:—The species first appears in Britain in the late pleistocene deposits of Ightham, Kent (see under *M. a. neglectus*).

Description:—*M. agrestis* may be known amongst European species by its moderate size (hind foot, 18 to 21; condylo-basal length of skull in adults, 25 to 28·7 mm.), and especially by its m^2, which has a well-developed postero-internal triangle forming a third inner angle.

In **form** and **appearance**, in which it is typical of its genus, it differs chiefly from *Evotomys* in its more robust, thicker build, less conspicuous ears, shorter tail, and duller tints.

The evenly rounded **ears** are hidden in the fur, and when laid forward reach about half-way to the eyes; the meatal lobes are well developed and reach a height centrally of about 3 mm. The small eyes are not prominent; they lie nearer the muzzle than the base of the ears. The tail is about one-third as long as the head and body. The mouth is small.

The **hands** and **feet** resemble those of *Evotomys glareolus*, but the minute thumb is almost concealed dorsally by the relatively large nail, and the hallux does not quite reach the base of digit two.

In the **tail** the annulations are pronounced but slightly irregular, their number about 20 to the cm. centrally; they show through the thin hairs, which, however, form a distinct terminal tuft.

The **skull** is moderately broad, the ratio of zygomatic breadth to condylo-basal length being from 55 to 60; the inter-orbital region develops a distinct ridge in adults; the length of the brain-case

measured from the inter-orbital constriction to the condyles is not less than the zygomatic breadth.

In the **teeth** the upper incisors project slightly ; the cheek-teeth are moderately large, with sharp salient angles and well-cut folds. In the maxillary series m^1 is decidedly the longest, m^2 and m^3 being subequal in crown-length. m^1 and m^2 are composed of the same elements as in *Evotomys*, but possess, the former variably, the latter invariably, a more or less reduced, supplemental postero-internal prism, forming a conspicuous and very distinctive third inner salient angle in m^2.

[European species with this pattern in m^2 have sometimes been placed in a sub-genus named *Agricola* or *Sylvicola*.]

m^3 begins with the usual transverse loop and three closed triangles ; its posterior loop is long, and cleft internally by a deep fold, so that in the simplest form the tooth terminates in a strongly crescentic formation ; it possesses three infolds with four salient angles on each side, of which the postero-external is weak and frequently obsolete. In a more complicated and rarer form the posterior inner fold extends across the loop to its outer side, thus isolating a second inner closed triangle followed by a simple posterior loop, which sometimes bears an incipient internal fold.

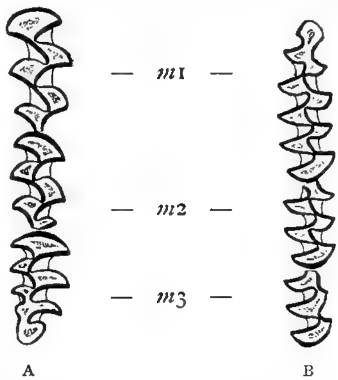


FIG. 65.—RIGHT CHEEK-TEETH OF *Microtus agrestis* (A, upper ; B, lower : 7 times life size.)

In m_1 the large anterior loop is cleft by a deep internal and, more posteriorly, by a shallower external re-entrant angle. This gives the tooth two anterior rounded projections, and behind them two shallow folds, in addition to the usual well-defined nine salient angles and seven infolds. Sometimes the shallow folds of the anterior loop may be deep enough to isolate a third outer triangle, so that the loop becomes a crescent resembling that of m^3 and a rudimentary sixth inner fold appears ; rarely there may be a supplemental fold on the extreme antero-external border. (See Fig. 65.)

m_2 is of the usual type, but as an abnormality its anterior external triangle may develop a slight inner basal projection so as to produce a small additional inner salient angle. In m_3 the salient angles and folds are bilaterally very unequal, being much deeper on the inner side, and with the antero-external angle usually obsolete.

Geographical variation :—There are seven more or less differentiated sub-species. Two have been described above under *Distribution*. The other five are British.

Status :—The arrival of a newer and more vigorous competitor in

M. hirtus is sufficient to account for the present restriction of the older *agrestis* to islands, mountains, and northern regions, where the competition is only moderately severe. In addition, the larger and extremely palatable forms of *Microtus* probably find a difficulty, like the lemmings, in escaping from their enemies in the absence of moderately heavy snow. They thus survive only where carnivora are scarce, or where the coarse herbage both feeds and protects them. This coarse herbage has no attractions for the newer dominant species, which prefer the richer diet more easily obtainable in warmer or more cultivated districts.

The British sub-species are as follows:—

MACGILLIVRAY'S GRASS MOUSE.

MICROTUS AGRESTIS MACGILLIVRAII, Barrett-Hamilton and Hinton.

1913. MICROTUS AGRESTIS MACGILLIVRAII, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Abstract Proc. Zool. Soc.*, London, No. 119, 15th April, 18, and *Proc. Zool. Soc.*, London, 1913, 831; described from Islay, Scotland; type specimen, No. 14.1.30.1 of British Museum collection.

Distribution and History:—This Grass Mouse appears to be confined to Islay, where the existence of a "vole" seems to have been first reported by T. F. Gilmour, who sent one found dead on 30th July 1905 to the editors of the *Ann. Scott. Nat. Hist.* (1905, 242). An immature specimen from Kildalton, too young for determination, was submitted by Kinnear to Miller (*Ann. and Mag. Nat. Hist.*, February 1908, 201); and three young found in a rick were forwarded to Thomas by Russell (*Zoologist*, 1910, 115), who did not think the animal common. A series of fourteen caught by Sheppard in the woods around Bridgend at once showed the distinctness of this mouse, which might well be called a species were it not that the sub-specific name indicates its relationships. Sheppard visited the island twice, and reported after his first visit that the animal was very scarce, as he was only successful in finding two colonies—one in a small belt of hazel, known as Dale Bush, the other in a walled graveyard about two miles south of Port Ellen, on the border of the district known as the Oa. On his second visit he found grass mice, shrews, and field mice all using the same runs in open ground overgrown with brambles, raspberries, and coarse grass.

Description:—MacGillivray's Grass Mouse resembles the more widely distributed *M. a. exsul* (next to be described) in size and general proportions, but may be recognised at all seasons by its much thinner coat (length of dorsal hairs reaching about 8 mm.) and duller coloration, especially on the under-side. The skull also shows some peculiar characters, as described below.

Colour:—The upper side is rich "buff," of a slightly duller tint than

in *M. a. exsul;* the under-side is almost devoid of the yellowish wash often so conspicuous in that form, and, owing to the thin pelage, the slaty hair-bases are frequently visible and take part in the general coloration.

The **young** have a dusky pelage in which there is very slight development of the light dorsal hair-tips. Those of the under-side are of a very light tint, increasing in depth towards the flanks and poll, where they are deepest, but never approaching the rich tints of adults; the dusky rump is in contrast to the back.

The **skull** (as compared with that of *M. a. exsul*) is distinguished by its deeper rostrum, lighter jugals, and more nearly vertical occiput; in correlation with the latter the interparietal is longer antero-posteriorly and has the posterior border straight instead of sinuous. Still more characteristic is the course of the temporal ridges on the anterior part of the brain-case, since they are never pushed backwards to the extent accruing in *exsul*, in aged specimens of which they are constricted anteriorly; the shape of the "shield" delimited by these ridges is therefore very different in the two forms (Fig. 66, 2 and 3).

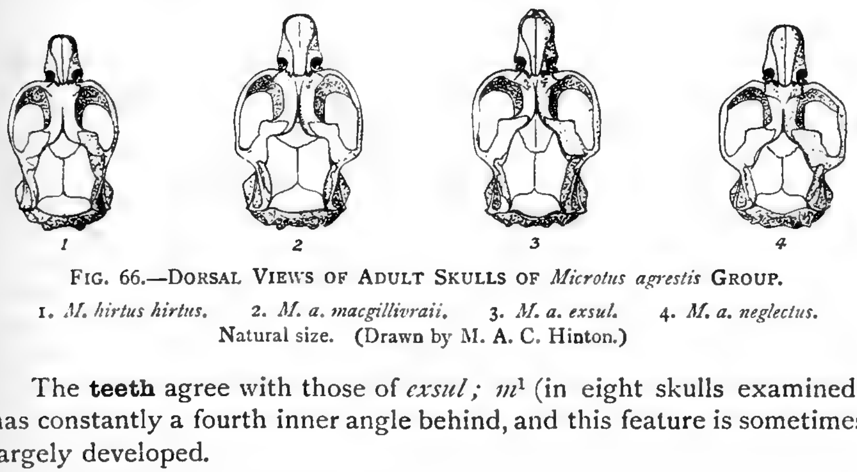


FIG. 66.—DORSAL VIEWS OF ADULT SKULLS OF *Microtus agrestis* GROUP.
1. *M. hirtus hirtus.* 2. *M. a. macgillivraii.* 3. *M. a. exsul.* 4. *M. a. neglectus.*
Natural size. (Drawn by M. A. C. Hinton.)

The **teeth** agree with those of *exsul;* m^1 (in eight skulls examined) has constantly a fourth inner angle behind, and this feature is sometimes largely developed.

Dimensions in millimetres:—Adult males (type, and two other old specimens): head and body, 125; tail, 32, 37, 40; hind foot, 19; ear, —, 15, 12. Adolescent: head and body, 115; tail, 34; hind foot, 19; ear, 12. Young: head and body, 90; tail, 27; hind foot, 18; ear, 10.

Skull:—Condylo-basal length, 26·4 to 28·7; breadth, zygomatic, 15·3 to 16·4; least inter-orbital, 3·6 to 3·8; mastoid, 11·8 to 12·6; occipital depth (median), 6·2 to 6·7; length of nasals, 7·6 to 8·7; of diastema, 7·2 to 7·8; of maxillary tooth-row, 6·6 to 7·1; of mandible, 16·2 to 17·6; of mandibular tooth-row, 6·3 to 6·7. (Except the least inter-orbital breadth, which decreases with age, the minimum values are those of immature, the maximum those of adult skulls, the subadults ranging between these extremes.)

Status:—This mouse, like the shrew and stoat of the island, is peculiar to Islay, which has evidently long been separated from the other islands and the mainland of Scotland. MacGillivray's Grass Mouse is slightly more primitive in pelage and skull than the other forms of *M. agrestis*, and so may be regarded as an insular survival rather than as a new development.

THE HEBRIDEAN GRASS MOUSE.

MICROTUS AGRESTIS EXSUL, Miller.

1908. MICROTUS AGRESTIS EXSUL, G. S. Miller, *Ann. and Mag. Nat. Hist.*, February, 201; described from North Uist, Outer Hebrides; type specimen, No. 6.3.1.3 of British Museum collection; Trouessart; Miller (*Catalogue*).

1909. MICROTUS AGRESTIS INSUL, R. Lydekker, *Zool. Record*, 1908, xlv., *Mamm.*, 74; accidental renaming of *exsul*.

History:—The occurrence of Grass Mice in the Inner Hebrides has long been known, but, with those of Orkney and the mainland, they have generally been lumped together as representing one widely distributed species. From South Uist they were first reported to Harvie-Brown by M'Donald of Rodil and Henderson of Loch Boisdale, and in 1879 Harvie-Brown himself captured a specimen at Newton, North Uist. The relationships of the Outer Hebridean form were, however, not recognised until Miller began his work for his *Catalogue*; his description of *exsul* was based on fourteen examples from North and South Uist, all of which except three had been taken by Kinnear, who supplied the first properly prepared specimens of this form. The presence of "voles" on other Scottish islands was also long known, having been mentioned by Alston in 1880; but, in the absence of systematic collecting, they could not be submitted to accurate study until the receipt of Sheppard's specimens in 1912. (See footnote on p. 422 *supra*.)

Distribution:—This is the Grass Mouse of the Hebrides generally, where it has thus far been found, often in abundance, on Arran (common, Alston), Gigha, Jura, Mull, Skye, North and South Uist, and Benbecula. In Jura it is sometimes so numerous as to be a danger to young plantations (Henry Evans, *in lit.*, 11th February 1900). It probably occurs also in other islands, as Rum (Millais). It is absent from Lewis (Duns, 1865, 620, and later writers), but there are distinct forms in Islay, Eigg, Muck, and Bute.

Description:—This large Grass Mouse differs from the Skandinavian *M. a. agrestis* only in the frequent presence of a small posterior fourth inner angle in m^1. From the Common Grass Mouse it may be distinguished by its much larger size and duller brown colour. From *M. a. macgillivraii* it differs in its slightly brighter colour, thicker pelage, and in the skull characters as already described above on p. 433.

The **fur** is soft and thick, the longer hairs of the back reaching a length of about 15 mm. in winter and the ordinary hairs about 12 mm., of which their light-coloured tips amount to about 2-3 mm.

The **colour** of the upper side is a clear brown, somewhere between "bister" and "ochraceous buff," yellower on the sides. The longer hairs are shiny black; the under-fur has tips 2 mm. long of dull—between ochraceous and cream—buff, the extreme tips often dusky. The under-side and feet are rather heavily washed with brownish, often light ochraceous, buff. The tail is bicoloured, especially in winter, when all the colours are lighter.

The **skull** is large and in old individuals strongly angular, developing a knife-like ridge in the inter-orbital region. The brain-case is short, the distance from the back of the inter-orbital constriction to the posterior surfaces of the condyles being barely equal to the zygomatic breadth. In old skulls the "shield" between the temporal ridges is considerably narrower anteriorly between its antero-external angles than at the level of the glenoid articulation (Fig. 66, 3).

In the **teeth** a small posterior fourth inner angle is usually present in m^1, having been found by Miller in ten out of fourteen skulls examined, by Hinton and myself in twenty out of twenty-one skulls;[1] in other sub-species this formation is very rare, being present in only eight amongst one hundred and thirty-six skulls.

FIG. 67.—RIGHT m^1 OF *Microtus agrestis exsul.*

Dimensions in millimetres (from actual specimens):—Old adult, 125—36—19—12; adolescent, 115—32—18—12; immature, 100—30—18—11; youngest examined, 60—15·5—14—5·5. The tail ranges in subadult to old specimens from 28 to 49. Females are found pregnant or nursing when they attain 109, before assuming adult pelage.

Skull:—Condylo-basal length, 26·5 to 28·6; breadth, zygomatic, 14·6 to 16·5; least inter-orbital, 3·2 to 3·5; mastoid, 11·6 to 12·5; occipital depth (median), 6·2 to 7·1; length of nasals, 6·8 to 8·4; of diastema, 7·4 to 8·1; of maxillary tooth-row, 6·5 to 7·0; of mandible, 16·5 to 18·0; of mandibular tooth-row, 6·4 to 7·0. (Except the least inter-orbital breadth, which decreases with age, the minimum values are those of immature, the maximum those of adult skulls, the subadults ranging between these extremes.)

Status:—This mouse is a moderately differentiated sub-species of the Skandinavian Grass Mouse, from which, as stated above, it can

[1] Small but distinct in nine; recognisable microscopically in eleven; entirely absent in one. This loop is also found occasionally in the North American *M. pennsylvanicus* (Ord), as figured by Miller, *N. Amer. Fauna*, No. 12, 23rd July 1896, fig. i. I have also figured it as an abnormality in *M. a. agrestis* (*Proc. Zool. Soc.*, London, 1896, 598).

only be distinguished by a peculiarity of the enamel-pattern, occurring as a normal feature, instead of, as in other members of the group, as a rather rare anomaly. If, however, a Scottish origin for the Skandinavian *Microtus agrestis* be accepted, the sub-species *exsul* is then geographically the more primitive, and it is quite natural to find the newer forms exhibiting a simpler and less primitive dentition. It is also natural to find *exsul* more closely related to the true *agrestis* of Skandinavia than are either *macgillivraii* or *neglectus*. None of these large forms are especially closely related to *hirtus* of England.

The **habits** are not known to differ from those of other Grass Mice. In Arran Mr R. W. Sheppard found the mice living mostly in scattered colonies on the edges of sheltered woods and young plantations of conifers on the north side of Brodick Bay; he met with no trace of them in the country around Blackwater foot. In Jura they frequented open pastures and had also runs through clumps of coarse grass at the edges of woods. In Mull they had scattered colonies on the cliffs above Tobermory on the western sides, at Croggan in open glades on hill-sides in natural woods, and on a hill at Buncosan, but were very scarce in all three localities.

In North and South Uist they are extremely abundant all over the hills, and in the sandy meadows or machars; in some localities they make a network of runs in the grass. Mr N. B. Kinnear has supplied sketches (Fig. 68) of the sleeping-places as found in small mounds in North Uist. These blind, somewhat circular, terminals to the burrows were always of the same shape and had their sides smooth, as if much used; they contained no grass or moss.

They seem to perform a seasonal migration, being most abundant in autumn on the lower grounds and near farms, while in summer they are distributed all over the uninhabited districts.

In North Uist Mr J. G. Millais has seen the collie dogs hunting them all day long, when not actually engaged in work, and a collie once stuffed himself so full of them that he was sick.[1]

They are hardy and do not hibernate [I have seen Skandinavian specimens of *agrestis* taken in a forest with 2 feet of snow on the ground].

The habits of the Norwegian form are given with much interesting detail by Robert Collett, but cannot be quoted here. It is evident that in northern countries of heavy snowfall, the habits are quite distinct in many respects from those prevalent in more southern districts. Nowhere, however, is there any hibernation, the mice being, like lemmings, active under the snow in winter.

[1] See p. 432 *supra*. Cocks (in Norway) had a setter very nearly die from bolting lemmings wholesale.

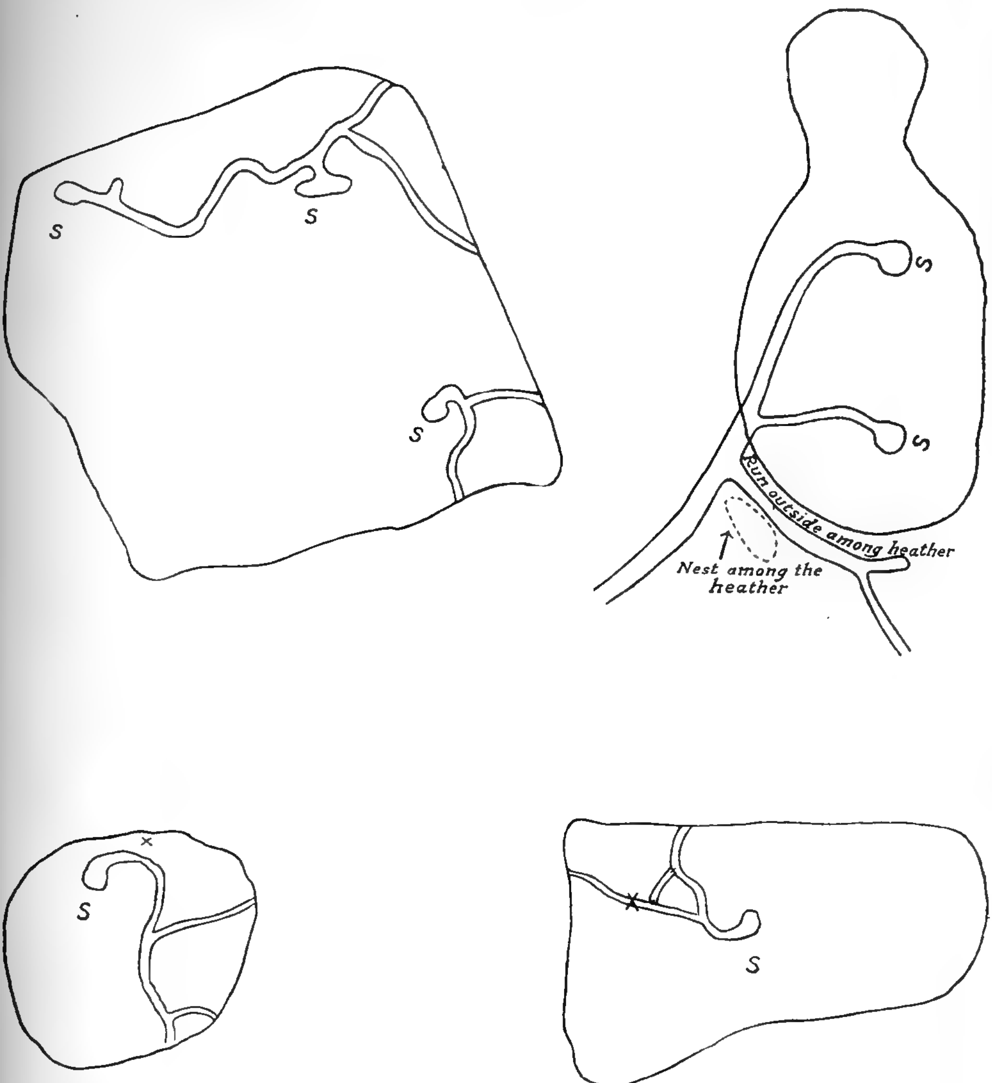


FIG. 68.—SLEEPING-PLACES OF *M. agrestis exsul* IN SMALL MOUNDS. (Sketched by N. B. Kinnear.)
S = Sleeping chamber; *X* = Patch of droppings.

THE EIGG GRASS MOUSE.

MICROTUS AGRESTIS MIAL,[1] Barrett-Hamilton and Hinton.

1913. MICROTUS AGRESTIS MIAL, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, October 1913, 364; described from Eigg, Scotland; type specimen, No. 14.1.30.3 of British Museum collection.

Distribution and History:—This mouse is at present only known from the island of Eigg, where it was first taken by Montague in March and April, and by Anderson in June 1913 (see footnote on p. 422 *supra*). Millais had previously suspected the occurrence of Grass Mice on Eigg.

Description:—*M. a. mial* agrees generally in size and proportions with *M. a. exsul*, but differs strikingly in pelage. The fur is longer and rather coarser in texture, so that the animal has a shaggy instead of a sleek appearance. This is due in great measure to the abundance and length of the long dusky hairs, which tend to darken the rump and flanks, leaving the general **colour** of the back very much as in *exsul*. The under-sides and the posterior surfaces of the hind legs are silvery in sharp contrast with the dark brown flanks; rarely the under-side shows faint traces of a median stripe of yellowish wash.

The **skull** differs from that of *exsul* of equal age in having the nasals and basioccipital relatively a little shorter, and the auditory bullæ slightly smaller.

The **teeth** are as in *exsul*. Amongst nineteen specimens, the fourth inner angle of m^1 was entirely absent in only one; in three it was represented merely by a microscopic vestige; in eleven it was small but quite distinct; and in four it was large and of regular form.

Dimensions in millimetres:—head and body (young to middle-aged), 98 to 116; tail, 27 to 39; hind foot, 17 to 20; ear, 10 to 13. In the type these items are respectively 113—36—20—12.

Skull:—Condylo-basal length of type (middle-aged), 27·4; breadth: zygomatic, 15·7; inter-orbital, 3·5; mastoid, 11·8; occipital depth, 6·3; length of nasals, 7·2; of diastema, 7·8; of maxillary tooth-row, 6·4; of mandible, 17·9; of mandibular tooth-row, 6·3.

Status:—This mouse, as is shown most clearly by its dental and cranial characters, has its nearest ally in *M. a. exsul*. It may be regarded as a peripheral and local development of the latter, which has arisen probably as a result of segregation for a long time upon a small island.

Habits:—Montague found this mouse common amongst coarse heather; it is not strictly nocturnal.

[1] *Mial* in Scotch Gaelic is the general word for beast.

THE HIGHLAND GRASS MOUSE.

MICROTUS AGRESTIS NEGLECTUS (Thompson in Jenyns).

1841. ARVICOLA NEGLECTA, William Thompson in Leonard Jenyns, *Ann. and Mag. Nat. Hist.*, 270, June; described from moors near Megarnie (*sic*), *i.e.*, Meggernie Castle, Perthshire, Scotland.

1857. ARVICOLA AGRESTIS (b.), ARVICOLA NEGLECTA, J. H. Blasius, *Säugethiere Deutschlands*, 369 (part).

1896. MICROTUS AGRESTIS NEGLECTUS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 598 and 606 (part); Trouessart (part); Miller, *Catalogue*.

Local names (non-Celtic):—*grass mouse*, *hill mouse*, *meadow mouse*, *water mouse* (the latter *fide* E. R. Alston), i.e., *earth hound* (Taylor).

(Celtic):—*luch-fheoir* or *luch-an fheoir*="grass mouse," is used indiscriminately for all mice in Scotland, as is *fiolagan* in Arran (C. H. Alston).

History:—Although described by Thompson in a paper by Jenyns in 1841, it cannot be said that the original description added anything to knowledge. In fact the name *neglectus*, although first applied to the highland form of true *agrestis*, was actually transferred by de Sélys and many subsequent writers, including myself, to the small southern *hirtus*. The synonymy and relationships are now, however, clear, mainly as the result of the work of Miller and of Hinton in different fields of mammalogy, and of Ogilvie-Grant in organising a collection of Scottish mammals.

Distribution:—This is the Grass Mouse of the Highlands of Scotland, where it is widely distributed and common in all suitable localities to the highest summits of the mountains, as, for instance, around and in the observatory buildings on Ben Nevis at 4400 feet (Bruce, *Ann. Scott. Nat. Hist.*, 1896, 187). It is not definitely known exactly where *neglectus* ends and *hirtus* begins. Service's (*Journ. cit.*, 1903, 68) and W. Evans's remarks on the distinctness of hill and lowland specimens in the Solway and Edinburgh districts suggest that *neglectus* ranges to the hills of south Scotland, and I have seen specimens from Lanarkshire taken by Kinnear. Millais probably alludes to these two forms when he states that, although English specimens vary very little in colour, immediately the Border is crossed, beginning with Wigtownshire and the Cheviots, two very distinct types are found, one larger and greyer on the hills, the other smaller and redder and with thinner coat on the low ground. Millais believes that the distinctions are accentuated as one goes north, but that the succession of "intermediate varieties is so continuous and so well-connected that it is impossible to create a dividing line." The question

requires further investigation. *M. a. neglectus* probably occurs on the coastal islands, having been taken by Sheppard on Bute (see *Proc. Zool. Soc.*, London, 1913, 833), where it occupies marshy ground south of Kilchattan, and the road-sides in the extreme south of the island.

Distribution in time:—According to Hinton, *M. a. neglectus*, or a similar form, appears first in the late pleistocene Fauna of Ightham Fissure, Kent, while *M. hirtus* is only known in more recent times.

Description:—This Grass Mouse is as large[1] as its relatives of the islands, differing from *exsul* chiefly in having, on the average, a simpler m^1; besides being much larger than *M. hirtus* of England it is more heavily furred, and has the upper surface darker and browner. The light bars of the hairs are near "ochraceous buff" approaching tawny, and the resulting colour of the pelage is near "prouts brown," with suggestions of "burnt umber" and "raw umber"; the under-side is some shade of dull grey, or may be lightly washed with yellowish or "wood brown." A male taken by Sheppard on 24th July 1908, was **moulting**.

The **skull** of young adult and middle-aged specimens is larger than that of *M. hirtus*, having a condylo-basal length of 25·4 to 26·6 mm. At this stage it resembles that of *M. a. exsul* of similar size, but has smaller bullæ, as in *M. hirtus*. In old age it attains a condylo-basal length of from 27·5 to 28·1 mm. or more, and the distinction from *M. a. exsul* in respect of the bullæ is less striking.

The **teeth** are of the normal form; m^1 is usually without any trace of the fourth inner angle, but occasionally a vestige of it is present in the larger specimens; it never attains the size sometimes attained in *exsul*.

Dimensions in millimetres:—Immature female, 109—37—18—13; subadult male, 118—42—17·5—12; old male, 128—40—19—16.

Skull:—Condylo-basal length, 25·4 to 28·1; breadth, zygomatic, 14·4 to 16·1; inter-orbital, 3·2 to 3·6; occipital, 11·2 to 12·8; depth, median occipital, 6·2 to 6·9; length of nasals, 7 to 8·1; of diastema, 7·2 to 8; of mandible, 16 to 17·5; of maxillary tooth-row, 6·5 to 7; of mandibular tooth-row, 6·2 to 6·5.

Status:—*M. a. neglectus* is a little less primitive than the Hebridean *exsul* in that its m^1 is slightly more reduced; like *exsul* and the other British sub-species, it is, however, intimately related to the true *agrestis* of Skandinavia. The differences between them appear mainly to be due to a long-continued segregation. The close relationship of these North British and Skandinavian forms is parallel to that of the Varying Hares, of which *Lepus timidus scoticus* agrees closely with *L. t. timidus* of Skandinavia; but there are no Irish Grass Mice to repeat the relationship between *L. hibernicus* and the extinct pleistocene *L. anglicus*.

[1] Miller and other writers never examined full-grown specimens.

THE MUCK GRASS MOUSE.

MICROTUS AGRESTIS LUCH,[1] Barrett-Hamilton and Hinton.

1913. MICROTUS AGRESTIS LUCH, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, October 1913, 366; described from Muck, Scotland; type specimen, No. 14.1.30.2 of British Museum collection.

Distribution and History:—This Grass Mouse is only known from three specimens taken on the island of Muck by Montague (see footnote on p. 422 *supra*). It was found in short heather on the edge of a cliff, where it appeared to be scarce. Millais had previously suspected the existence of Grass Mice on the island.

Description:—It is a quite distinct form, differing from *exsul* in its smaller size, in which it approaches *hirtus*; agreeing with *mial* in its only slightly less dense and shaggy coat, and with *neglectus* in its skull and teeth; and being quite peculiar in its conspicuously buff under-side. The **colour** of the back is similar to that of *mial*, but owing to the long black hairs becoming fewer and shorter laterally, the flanks are lighter than those of the Eigg form, their colour gradually passing into the heavy buff wash which extends all over the ventral surface of the body and tail. This buff under-side is, however, here and there darkened to a small extent by the slaty bases of the hairs which show through.

The **skull** cannot be distinguished from that of small examples of *neglectus*; it differs quite strikingly from that of *mial* in its smaller size, relatively greater zygomatic breadth, broader brain-case, and longer basioccipital.

The **teeth** of the three specimens examined are normal, m^1 having no trace of a fourth inner angle.

Dimensions in millimetres of, respectively, a fully adult male (type of the sub-species), a male, and an adult female:—head and body, 110, 108, 105; tail, 33, 32, 33; hind foot, 18, 17·5, 18; ear, 11·5, 11, 11.

Skull (of the type):—Condylo-basal length, 26; breadth, zygomatic, 15·5; inter-orbital, 3; mastoid, 11·8; occipital depth, 6·6; length of nasals, 7·2; of diastema, 7·2; of maxillary tooth-row, 6·3; of mandible, 16·8; of mandibular tooth-row, 6·1.

Status:—This mouse must apparently be regarded as a dwarfed insular development of *M. a. neglectus*, the form inhabiting the neighbouring Scottish mainland. The occurrence of an animal with such relationships on Muck is remarkable, because on the closely adjacent Eigg, as on Skye, Mull, Jura, Islay, Gigha, and Arran, the Grass Mice are either identical with *exsul*, or more nearly related to it than to *neglectus*. It would seem from the above facts that Eigg and

[1] *Luch* in Gaelic means "mouse."

Muck have been for a very long period separated from each other, and that Muck has been in connection with the mainland more recently than most of the other islands.

THE COMMON GRASS MOUSE.

MICROTUS HIRTUS (Bellamy).

MICROTUS HIRTUS HIRTUS (Bellamy).

1769. MUS TERRESTRIS, John Berkenhout, *Outlines of the Natural History of Great Britain and Ireland*, i., 5 (part); not *Mus terrestris* of Linnæus (1758)=*Arvicola terrestris*.

1807. MUS ARVALIS, W. Turton, *British Fauna*, 12 (part); Bingley; Donovan; not *Mus arvalis* of Pallas, 1778.

1828. ARVICOLA AGRESTIS, John Fleming, *A History of British Animals*, 23 (part); Yarrell, *Proc. Zool. Soc.*, London, 1832, 109; Jenyns; Bell, edd. 1 and 2; MacGillivray; de Sélys-Longchamps; Owen; Morris, *Cat. Brit. Foss.*, ed. 2, 1854, 357; Sanford, *Quart. Journ. Geol. Soc.*, xxvi., 1870, 124; Blackmore and Alston; Lydekker, *Cat. Foss. Mamm. Brit. Mus.*, i., 232; Flower and Lydekker; Winge; Lataste, *Le Naturaliste*, 15th October 1883, 349.

1839. ARVICOLA HIRTA, J. C. Bellamy, *Natural History of South Devon*, 373; described from Yealmpton, Devonshire, England.

1841. ARVICOLA ARVALIS, Leonard Jenyns, *Ann. and Mag. Nat. Hist.*, June 1841, 269 (part).

1847. ARVICOLA BRITANNICUS, E. de Sélys-Longchamps, *Revue Zoologique* (Paris), 307, October; described from England and Scotland; also, *Atti della Ottava Riunione degli Sci. Ital.* (Genoa, 1846), 495, 1847.

1857. ARVICOLA AGRESTIS (b.), ARVICOLA NEGLECTA, J. H Blasius, *Säugethiere Deutschlands*, 369 (part)

1883. MICROTUS AGRESTIS, A. Smith Woodward and C. D. Sherborn (part); Lydekker; Barrett-Hamilton, *Proc. Zool. Soc.*, London, 1896, 602; Aflalo; Johnston; Thomas, *Zoologist*, 1898, 264; Millais; Pycraft, *Guide to British Vertebrates*; Trouessart.

1896. MICROTUS AGRESTIS NEGLECTUS; G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 602 (part); Trouessart (part).

1912. MICROTUS AGRESTIS HIRTUS, G. S. Miller, *Catalogue of the Mammals of Western Europe*, 673.

1913. MICROTUS HIRTUS, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Proc. Zool. Soc.*, London, 834.

Le Campagnol of the French; *Die Erdmaus* of the Germans.

The **synonymy** is that of the British form of *M. hirtus*. The older names, having been applied before segregation had taken place, include more than one form. The use of the specific name *arvalis* is due to confusion with the common continental species of that name, and *britannicus* arose from the same error, de Sélys-Longchamps having believed his *britannicus* to be the British representative of *arvalis*, with which alone he compared it. There can be no doubt about the application of the word *hirtus*, once the south British Grass Mouse is accepted as a distinct form.

Terminology:—Grass Mice are known under the following names in works on British mammals:—"Short-tailed Field Mouse" (Pennant, *Brit. Zool.*, ed. 2, 104, 1768; Berkenhout, 1769; Bingley, 1809, alternative to "Meadow Mouse"; Bell 1837, alternative to "Meadow Mouse" and second to "Field Vole"). "Meadow Rat" (Pennant, *Quad.*, 33, *n.* 322). "Meadow Mouse" (Pennant, *Quad.*, ii., 205; Kerr, *Animal Kingdom*, 1792, 238; Turton, 1807; Bingley, 1809, alternative to "Short-tailed Field Mouse"; Bell, 1837, alternative to "Short-tailed Field Mouse" and second to "Field Vole"). "Brown Short-tailed Field Rat" (Donovan, 1819). "Field Vole" (Fleming, 1828; Bell, 1837; Aflalo, 1898). "Field Campagnol" (Jenyns, 1835), from the French. "Brown" or "Field Vole" (MacGillivray, 1838). "Common Field Vole" or "Field Vole" (Bell, 1874; Lydekker, 1895; Millais, 1905). "Short-tailed Field Vole" (Johnston, 1905). "Common Meadow Mouse" (English).

It appears that the oldest name used by British naturalists for this animal was some form of "Short-tailed Field Mouse" or "Short-tailed Field Rat," alternating, however, freely with "Meadow Mouse," a name which is established in North America. The word "vole" = a "field," a mutilated form of "vole-mouse," appears to have been borrowed to form an English generic name by Fleming (1828) from Barry (1805), who reported it as in use in the Orkneys (see also below, p. 457). Apparently the need of some such name was felt at that period, for in 1833 Jenyns took the term "Field Campagnol," from the French. This is mentioned by MacGillivray, who declared his preference for "vole." The adoption of the latter term by Bell and MacGillivray led to its appearance in one form or another in almost every subsequent work, and it has now found what seems to be a permanent place in the technical zoological literature of the English-speaking peoples of both hemispheres. But it is quite unknown to the public and may be conveniently discarded as a specific name. The name "Grass Mouse" is very extensively used locally, and as stated above on p. 398, it is here proposed to restrict the word "vole" to the group *Microti*. The subject is discussed also by Elliot (*Proc. Berwickshire Nat. Club*, viii., 1876-1878, published 1879, 447-468); by Harting (*Zoologist*, 1893, 145); Skeat and Maxwell (*Notes and Queries*, 16th September and 21st October 1899); and by English; other references are given in dictionaries, but I have been unable to find them.

Local names (non-Celtic):—Usually *grass* or *meadow mouse*, but occasionally *harvest mouse*, as in Shropshire (Forrest); *bob-tail* or *bull-dog mouse* of Surrey (Adams); *pig mouse* (Lydekker); *waggoner* (Cocks); *water mouse* (E. R. Alston).

Welsh:—*Llygoden gwtta'r maes* (Millais); *llygoden gynffbyr* = short-tailed mouse (Forrest); but species are not usually distinguished in Gaelic dialects, *pathew* or *bathor* being also applied to mice in Wales (Caton Haigh in Forrest).

History:—Although described by Bellamy in 1839, it cannot be pretended that the status and affinities of this mouse have been made at all clear until quite recently. All the earlier descriptions, even when technically valid, must be regarded as due to misapprehensions, the earlier writers not having been acquainted with the true relationships of *agrestis* and the continental *arvalis*.

The exact **distribution** of this Grass Mouse is imperfectly known, but it certainly ranges from Wales to Austrian Galicia, ascending to 4000 feet in Switzerland (Fatio). The common European form, which is found from the eastern shores of the English Channel and the Baltic at least to Central Germany and South-western France, is just distinguishable as a sub-species, *M. h. bailloni* (de Sélys), on account of its narrower skull. Another sub-species, *M. rozianus* (Bocage) of Portugal and North-western Spain, which differs chiefly in its small auditory bullæ, is graded as a sub-species of *agrestis* by Miller, but may prove to be more nearly related to *hirtus*.

M. hirtus is the Grass Mouse of England, Wales, and the lowlands of Scotland, where it is common all over the country, including the islands of Wight and Anglesey, except in woods and on the higher hills. In the Highlands of Scotland and probably on the hills of the south, also in the Hebrides, it is replaced by one or other of the forms of *M. agrestis*, and in the Orkneys by *M. orcadensis*. It is absent from Ireland, the Isle of Man, Bardsey Island, and, as far as is known, from all other islands except those mentioned above.

Distribution in time and **Status**:—This mouse is not known as a fossil in Britain, although remains of "voles" are numerous in late pleistocene deposits. It is therefore probably a quite recent post-pleistocene immigrant, which appears to have established itself in the more low-lying and southern parts of the country, at the expense of the older forms of the *M. agrestis* type, in a manner paralleled by that of *Lepus europæus* and *Evotomys glareolus*. It appears to have arrived in Britain before the separation of Wight and Anglesey, but after that of all the other islands.

Description:—The Common Grass Mouse is distinguishable in its genus by its comparatively small size (hind foot, 17 to 18, and condylo-basal length of skull not more than 24·6 to 26 mm.), small bullæ, and comparatively reddish upper side.

The **colour** of the upper side is near "tawny russet," very indistinctly overlaid with black. The sides are paler and washed with buff; the under-side and feet are light ochraceous buff, through which colour the dusky basal portions of the hairs show here and there. The tail is bicoloured, above brown, beneath like the belly.

The brightest individuals run very near *Evotomys glareolus*, but lack the clear light belly of the latter.

The **skull** resembles that of *M. a. exsul*, but is smaller and has relatively smaller bullæ.

The **teeth** are quite like those of normal *agrestis*, m^1 being without a small fourth inner angle.

Exceptional variation:—White varieties are not common, but there are a number of records of specimens exhibiting various degrees of albinism, a few quite white with pink eyes, the rest in intermediate conditions from cream to piebald. A black variety was recorded by Southwell (*Zoologist*, 1890, 216).

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
SPECIMENS FROM REIGATE, SURREY, CAUGHT AND MEASURED BY L. E. ADAMS.					
SEXUALLY IMMATURE OF BOTH SEXES:—					
1. 19th May 1912, average of 5 fœtuses ready for birth	34	..	..	..	..
2. 17th July 1912, average of 4 in nest; umbilical cord still showing	40	12	9	4	3
3. 10th July 1912, average of 6 in nest; slight down on back; umbilical cord showing on 2	45	12	9	5	3·5
4. 15th June 1912, average of 7 in nest; furred above and very slightly below; eyes and ears closed	46	12·5	10	5	3·5
5. 15th June 1912, average of 7 in nest; completely furred, ears closed, eyes opening	54	14	12	5	4·5
6. 9th July 1912, average of 4 in nest; completely furred, eyes and ears closed	56	15	13	6·5	5·5
7. Male, 11th July 1912; eyes and ears open	56	17	15	7	5·5
8. Female, 30th May 1911; juvenal pelage; vagina perforate	78	24	15	11	12
9. Male, 1st June 1911; juvenal pelage	78	28	16	11	12[1]
10. Male, 28th Sept. 1912; juvenal pelage	81	29	16	10	16[2]
11. Female, 30th Oct. 1911; adult pelage	82	30	16	10	15[3]
12. Male, 9th Oct. 1912; adult pelage	83	29	16	10·5	16[4]
13. Male, 31st Oct. 1911; adult pelage	83	34	17	10	14[5]
14. Female, 28th Sept. 1912; adult pelage	85	28	17	10	16[6]
SEXUALLY MATURE MALES:—					
1. 26th May 1911	104	38	16·5	12	31
2. 2nd June 1911	108	46	18	12	28·5
3. 2nd June 1911	100	38	16	11	24
4. 10th June 1911	96	32	16	11	23
5. 11th June 1911	101	35	17	11	31
6. 11th June 1911	110	39	16	11	29
7. 17th June 1911	115	34	16·5	11	25
8. 10th July 1911 (largest ever measured by Adams)	118	40	17	11	30
9. 15th July 1911	87	32	15	11	19
10. 30th Oct. 1911	101	38	18	11	24
11. 6th Nov. 1911	96	38	17	11	21
12. 14th May 1912	99	32	16	12	32
13. 14th May 1912	104	38	17	12	34
14. 15th May 1912	98	36	17	11	25
15. 16th May 1912	89	34	17	11	19
16. 17th May 1912	104	36	16	11	33
17. 18th May 1912	103	34	16	12	32
18. 18th May 1912	101	33	17	12	34
19. 19th May 1912	95	35	18	11	25
20. 21st May 1912	108	31	17	12	28
Average	101·5	36	16·7	11·8	27·4

[1] Testis 2 mm. in diameter. [2] Testis 1 mm. in diameter. [3] Imperforate.
[4] Testis 1 mm. in diameter. [5] Testis 2 mm. in diameter. [6] Imperforate.

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
SPECIMENS FROM REIGATE, SURREY (*continued*).					
SEXUALLY MATURE FEMALES:—					
1. 14th June 1909; 3 small fœtuses	82	30	16	..	..
2. 23rd June 1909; 6 small fœtuses	98	35	16	..	..
3. 12th July 1909	85	30	16	..	..
4. 15th July 1909; 6 small fœtuses	84	25	14	..	..
5. 20th July 1909; 7 small fœtuses	96	34	16	..	..
6. 24th July 1909; 5 small fœtuses	94	33	15·5	..	..
7. 2nd Oct. 1909; 5 small fœtuses	112	41	17·5	..	..
8. 11th Oct. 1909; 4 small fœtuses	94	32	16	..	..
9. 1st June 1911; 5 small fœtuses	104	41	16·5	11·5	33
10. 3rd June 1911; 3 small fœtuses	94	36	16	10	20
11. 29th Aug. 1911; 5 small fœtuses	100	36	16	11·5	29
12. 24th Sept. 1911; 2 small fœtuses	84	53	16	12	17
13. 29th Oct. 1911	94	32	16	11	19
14. 19th May 1912; 5 large fœtuses, head and body of which averaged 34	97	38	16	11	35
15. 13th June 1912; 6 small fœtuses	97	25	16	11	22
16. 20th Sept. 1912	96	32	16	11	20
17. 28th Sept. 1912; 3 small fœtuses	88	29	17	11	23
18. 10th Oct. 1913	92	34	17	11	25
19. 18th Oct. 1913	90	34	17	10	18
20. 21st Oct. 1913	98	40	17	12	27
Average	93·5	34·5	16·3	11	24

Notes on tables of dimensions:—The young make occasional excursions from the nursery as soon as they can see, but frequently retain it as their headquarters until they attain sexual maturity, which is not usually until the head and body reaches a length of 90 to 95.

Specimens with the head and body exceeding 110 are rare, but probably represent the size regularly reached by really old animals. Occasionally, even larger specimens are captured; *e.g.*, a male with head and body 123 (Coward, Cheshire). A female nursing young, but not fully grown, sent by the late Lord Lilford from Oundle, Northamptonshire, reached 117 (for further details see my paper in *Proc. Zool. Soc.*, London, 19th May 1896, 599). The status of these "giants" requires investigation. Evidently "voles" continue to grow for a long and somewhat indefinite period (*cf.* above, under *Evotomys*, p. 411).

Skull:—Condylo-basal length, 24·4 to 26; breadth: zygomatic, 14 to 15·2; inter-orbital,. 3·0 to 3·4; occipital, 11 to 12·2; depth, median occipital, 6 to 6·8; length: of nasals, 6·6 to 7·4; of diastema, 6·8 to 7·8; of mandible, 15·2 to 16·2; of maxillary tooth-row, 5·8 to 6·4; of mandibular tooth-row, 5·8 to 6·4.

Grass Mice[1] are gregarious and sociable animals, restricted under normal circumstances to a diet of green stuff, preferably

[1] For an excellent account of the habits of Grass Mice, see Victor Fatio's *Les Campagnoles du Leman.*

the succulent bases of grass-stalks.[1] They are, however, capable, when opportunity or necessity arises, of adopting at least partially the omnivorous propensities of the Bank Mouse, and are frequently unable to resist the temptation offered by a dead body, even of one of their own kind. For the satisfaction of their wants, therefore, many different kinds of country are suitable, the main requirement being plenty of grass, which may be of any coarse kind, for their teeth are excellent slicing organs. They may be found in pastures, especially in those damp or wet places where growth is most

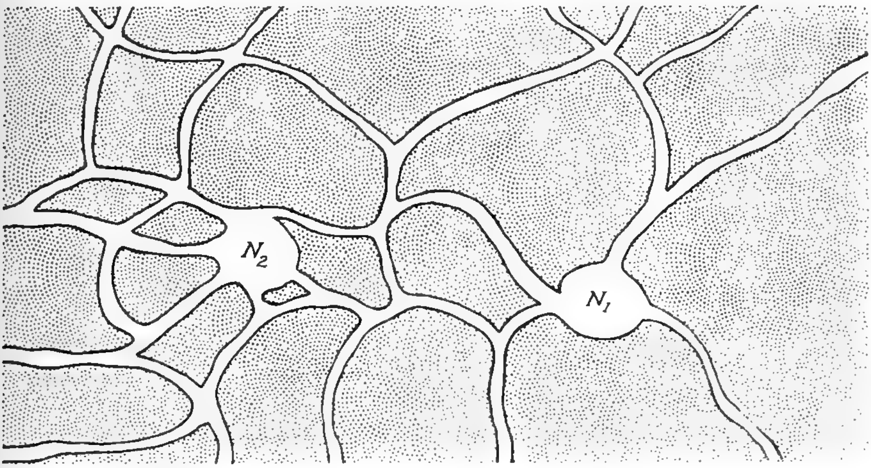


FIG. 69.—PLAN OF RUNS OF GRASS MICE UNDER A FALLEN NOTICE-BOARD, 23rd January 1910. Diagrammatic, from sketches by L. E. Adams. N_1 and N_2 nursery, with young and nest in each; scale 8 feet.

luxuriant; on salt marshes; amongst the marram-grass of sea-beaches;[2] on moors and mountains and, especially in winter, in open patches in woods, or on grassy hedgerows in almost every conceivable situation.

Where vegetation is thick they construct a labyrinthine network of runs, apparently the common property of the

[1] Hence they can rarely be induced to enter a trap containing the usual baits, but are attracted by carrots (L. E. Adams) or bulbs of yellow crocus (W. R. Ogilvie-Grant), neglecting those of any other colour. They are easily caught in unbaited traps so placed in their runs that the animals attempt to pass through them.

[2] G. T. Rope (*Zoologist*, 1873, 3610) found them very numerous on small grassy islands; and abundant and attaining "a very large size" on a long water-bound strip of beach at Aldeburgh, Suffolk.

colony, lying partly above and partly below ground. They weave loose nests of grass for the reception of their young. In winter or early spring these nurseries are more frequently placed under ground or in sheltered places under logs or piles of wood; they are then sometimes lined with warmer materials such as fur and wool. In summer they are usually on the surface, invariably composed of grass, and are often very evident in hayfields by clogging the knives of the reaping machines.

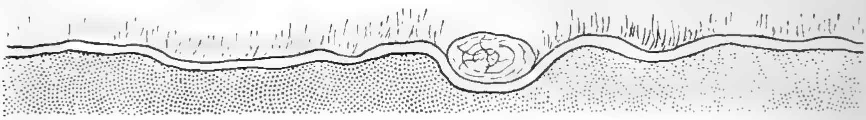


FIG. 70.—HORIZONTAL SECTION OF RUN OF GRASS MOUSE PASSING UNDER A LOG. From a sketch by L. E. Adams; scale 10 feet.

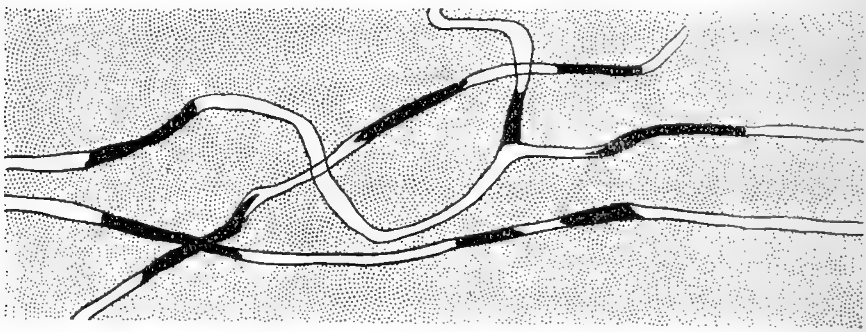


FIG. 71.—PLAN OF RUNS OF GRASS MICE IN COARSE GRASS, partially above and partially (where blackened) below ground. From a sketch by L. E. Adams; scale 12 feet.

These mice are very hardy and never hibernate, although they may be comparatively inactive in cold, damp weather. In winter they often seek more sheltered habitats than the open fields, and have been caught occasionally in cellars and outhouses; but never habitually resort to ricks and granaries. Like other small mammals, they probably suffer more from hard "black" snowless frosts and summer droughts than from snow, which makes the work of burrowing actually easier and protects both vegetation and mice from the cold.[1] In captivity the male may safely be left with his own wife and children, though he will devour strange litters, which suggests that the

[1] For the habits of "voles" in times of snow, see C. Hart Merriam, *Mammals of Adirondacks*, II, 124.

mice live together in pairs,[1] or at all events have some sense of property in their nests. They have also some sense of sanitation, since they deposit their ordure in little heaps at particular places, as at the mouths of their burrows. The rest of their life-history is soon told. Although not incapable of climbing, and extremely agile without being fast, they never under normal circumstances leave the ground, and may be seen running, but not bounding or jumping, to and fro in their haunts, or sitting at little bare places at the mouths of their burrows, at almost any hour of the day ; and no doubt they are equally active at night. They probably spend their time alternately in short sleeps and meals, their light slumber guarding against surprise. They are quite capable of amassing stores of food for winter use, always of such provender as will keep, but for obvious reasons this propensity is not very highly developed in the comparatively mild climate of England.

They are copious drinkers and their appetite is enormous, Dr Henry Laver having ascertained[2] the weight of clover consumed by a single captive individual in one day to be six drachms (apothecary's weight = 2.3 grammes).

They are very attentive to their fur, cleaning it carefully after the manner of a cat.

At intervals, either owing to favourable weather[3]—moist summers and mild winters resulting in exceptionally nourishing vegetation—but perhaps occurring independently in a natural cycle, the numbers of Grass Mice undergo a very exceptional increase, beginning gradually and extending over several years if unchecked. More litters, and those of abnormal size, make their appearance, and presently the usual equilibrium between mice and vegetation is upset, the grass is all consumed, the mice, usually in autumn, begin to stray into woods, bark[4] trees, cut their roots, otherwise cause damage, and people become aware that it is a "vole year" or that there is a "plague" of mice. With the increased numbers there ensues

[1] Adams has taken 73 males to 24 females, a proportion of, roughly, 3 males to 1 female; but the figures, although suggestive, are too small to form the basis for a definite statement as to the relative numbers of the sexes.

[2] *Zoologist*, 1881, 461. [3] R. Service, *Ann. Scott. Nat. Hist.*, 1892, 134.

[4] Charles Oldham (*Zoologist*, 1890, 98) once observed them engaged in barking hollies.

a corresponding abundance of beasts and birds of prey, to which (and to dogs) the mice are extremely palatable. These participate in the exceptional fertility of their victims, and for the time being, alter the whole routine of their ordinary breeding habits. Later, disease arrives to help in the extermination of the mice, fertility drops to a minimum, the predatory creatures retire or starve, and vegetation resumes its normal aspect; the "plague" is now over. Such occurrences are now infrequent in Britain,[1] but so recently as 1891-93 the grazing lands of southern Scotland were afflicted to an extent involving

[1] Plagues of mice have been known at least from the time of Aristotle (*Historia Animalium*, vi., 37) and Sennacherib, the defeat of whose army owing to the destruction by night of their quivers, arrows, and bowstrings was described by Herodotus (*Euterpe*, ii., 141). A fuller account of these and other classical references was given by J. E. Harting (*Zoologist*, 1893, 187), and see also J. G. Frazer's *Golden Bough* (*cit. supra*, p. 374). For Britain there are records of "sore plagues of strange mice," in the following years at least:—1580-81, "an extreme dripping warm year, and a mild moist winter" (Childrey), in Danesey Hundred, South Minster, Essex (Holinshed's *Chronicle*, 1315); 1648, Hundred of Rochford and Isle of Foulness, Essex (Childrey, *Britannica Baconica*, 1660, 14). An anonymous correspondent to the *Gentleman's Magazine*, 1754, 215, stated that Helgay, near Downham Market, Norfolk, had a plague every six or seven years, at which times long-eared owls arrived regularly to eat the mice, and were venerated almost like the Egyptian ibises. Prior to 1813, near Bridgwater, Somersetshire (George Montagu, *Supplement to the Ornithological Dict.*, 1813, art. "Owl"); 1812-14 (commencing in 1810 or 1811), Forest of Dean, Gloucestershire, and New Forest, Hampshire (Lord Glenbervie, *Zool. Journ.*, i., January 1825, 433-44); 1825, oak-coppices of Cameron, Dumbartonshire (Harting, *Zoologist*, 1892, 121-38); 1836, Forest of Dean, Gloucestershire (Edward Jesse, *op. cit. supra*, p. 418); 1863-64, Rannoch, Perthshire (Harting, *op. cit.*); 1864-67, woods, Drumlanrig, Dumfriesshire (Harting, *op. cit.*); 1875-(culminating in) 76 (ending in May), mainly in portions of Roxburghshire, Selkirkshire, Dumfriesshire, and Yorkshire (Sir Walter Elliot, *Proc. Berwickshire Nat. Club*, viii., 1876-78, published 1879, 447-68, a paper abstracted for the *Brit. Assoc.*, 1878), and following winters of higher than usual temperature, the frosts being slight or accompanied by snow, from February 1871 to January 1876; commencing before 1890 and ending before the summer of 1893, Dumfriesshire, Roxburgh, Selkirk, Peebles, Lanark, Kirkcudbright (*Government Report on the Plague of Field Voles in Scotland*, 1893, 174, reprinted in *Zoologist*, 1893, 121-38; see also P. Adair, *Ann. Scott. Nat. Hist.*, 1893, 193-202; Harting, *Zoologist*, 1892, 161); simultaneously in 1891-92 a plague in Thessaly (*Report cit.* and Harting, *Zoologist*, 1893, 139-45), and in 1891-93 in Norway (Collett). [Plagues are said to have occurred in Essex and Kent in the 17th century, but I have not been able to find the original references.]

The above are well summarised in the *Report cit. supra*, as also by R. Lydekker; and for mouse plagues generally, see A. Fleming, *Animal Plagues*, Philadelphia, 1871; V. Bailey, *N. Amer. Fauna*, No. 25, 116; W. H. Hudson, *Naturalist in La Plata*, ed. 2, 1892, 60-64; S. A. Poppe, *Ueber die Mäuseplage*, 1902 (including a bibliography of murine literature); S. E. Piper, *Year Book, U.S. Department Agriculture*, 1908, 301-8.

an area of not less than sixty miles by twelve to twenty. Plagues on such a large scale must, however, be regarded as rare in Britain; on a small scale Service believed[1] them to be frequent, and in fact that of 1891-93 is said to have commenced in a small way in the autumn of 1887. Sometimes other species also are involved, as the Bank and Field Mice; a "run" of these two was observed by Mr A. H. Cocks[2] in 1900, and in the Forest of Dean plague of 1813-14 there was one Field Mouse to every fifty Grass Mice.[3]

It is doubtful if the recurrence of mouse-years can be attributed to the destruction by game preservers and others of the natural enemies of the rodents. In a state of nature the numbers of the latter fluctuate even more markedly and probably with greater regularity than under the artificial environment imposed by civilisation, and in some cases it appears that the carnivores depend on the rodents rather than the rodents on the carnivores. The reclaiming of woods, forests, marshes, and rough pastures which protect small rodents proceeds side by side with the destruction of predaceous creatures, and it is probable that a thorough and effective system of agriculture is the best preventative of mouse plagues.

There are few detailed accounts of the breeding habits of this species. Mr J. G. Millais has seen both sexes collecting material for a nest. The average number of young is probably about five, that number having been reported by Mr Adams as the result of examining thirty-eight litters made up as follows:—

No. of Litters.	No. of Young.	No. of Litters.	No. of Young.
1	9	5	4
5	7	8	3
8	6	1	2
9	5	1	1

and these results agree fairly well with those of other observers. Grass Mice do not, therefore, produce so many young at a time as the common rats and mice; still they rear a considerable number annually in a sexual season lasting at least from April to December. In times of "plague" the number of young may run higher per litter, Service having met with ten. A pair[4]

[1] *Ann. Scott. Nat. Hist.*, 1896, 206.
[2] See above, p. 418.
[3] Glenbervie, *op. cit.*
[4] Fernand Lataste.

of the allied *M. arvalis* produced five young in captivity at the age of eighty-eight days on 2nd March, five more on 6th July, and again five on 30th July. The latter opened their eyes when ten days old. On the 12th day, though still very small, they began to leave their nest. On the 26th day they appeared to be nearly "grown up." In other respects the breeding habits are not known to differ from those of other mice, it being uncertain whether they are monogamous or not. Probably in this respect their customs are as loose as in other gregarious mammals.

The voice, often used in moments of excitement or hunger, is half a grumble, half a squeak.[1] They do not seem to chatter their teeth and stamp their feet as some exotic species do.

In captivity these mice are far more amiable than Bank Mice. Perhaps owing to poor brain power, they become tame very soon after capture, and can with difficulty be teased into biting. The young have been reared by a Field Mouse under the care of Mr F. H. Parrott[2] and by a House Mouse.[3]

They are good swimmers. Mr Rope[4] has disturbed one amongst seaweed cast up by the tide, when it made for the water and swam out boldly. Mr Bruce Campbell has observed[5] some swimming for pleasure in the sea in the Firth of Forth, at Long Green Bay, Dalmeny.

Charles Darwin comments upon the dependence upon each other of Dutch and red clovers, humble-bees, and "field mice."[6] The clovers are fertilised by the bees, and the numbers of the latter in any district depend in a great measure on the number of "field mice," which destroy their combs and nests, according to Colonel Newman, to the extent of two-thirds all over England.

Darwin believed, again, that the number of mice is regulated by the number of cats, but here the correlation is doubtful; his remarks are often read as referring to Field Mice,[7] but the facts are probably true of several species, and the Grass Mouse is the most common in situations where humble-bees nest. Grass Mice also destroy a destructive sawfly,[8] which damages larch.[9]

[1] W. Evans. [2] Cocks. [3] Rope, *Zoologist*, 1883, 332.
[4] *Zoologist*, 1890, 330. [5] *Ann. Scott. Nat. Hist.*, 1901, 48.
[6] *The Origin of Species*, 6th ed., 37th thousand, 1883, 57.
[7] *Apodemus sylvaticus*. [8] *Nematus erichsonii* of Hartig.
[9] An exhibit to illustrate this fact was shown at the Royal Society's conversazione on 13th May 1908, by C. G. Hewitt.

Group ORCADENSIS.

Characters and status:—The Grass Mice of the Orkneys[1] belong to a peculiar group which appears to be an offshoot of a form not known in Britain, the continental *M. arvalis.* These are readily distinguished by their m^2, which differs from that of *M. agrestis* in lacking the small third or posterior inner angle, so that it possesses only four dentine spaces. They are all comparatively large animals with a tendency to develop exceptionally strong temporal muscles resulting in prominent modifications of the skull.

Miller regards these mice as belonging to two species, namely: *M. orcadensis*, inhabiting Pomona and the South Orkneys, and *M. sandayensis* (with two sub-species, viz., *M. s. sandayensis* from Sanday, and *M. s. westræ*, from Westray), living in the North Orkneys. Further specimens, including many old individuals, recently taken by Ogilvie-Grant on Sanday and Rousay, enabled Hinton (whose work was done since the key on pp. 377-381 was published) to show that Miller's arrangement cannot be sustained, and that all the Orkney Grass Mice must be referred to a single species—*M. orcadensis.* It appears that, as a result of long segregation in small islands, in this respect affording a complete parallel with the *agrestis* group in the Hebrides, the Orkney mice have become differentiated into at least five closely allied sub-species.

With *M. orcadensis* must be associated *M. sarnius*[2] of Guernsey, Channel Islands, and the extinct late pleistocene *M. corneri*,[3] the remains of which occur at Ightham, Kent, and possibly also in France; whether any continental forms have similar affinities remains for future work to decide.

Hinton has shown that the cranial modifications of the *orcadensis* group are dependent upon the strength and size of the temporal muscles. In the young these muscles are feeble. Consequently young skulls of all members of the group are similar to each other, and have a brain-case resembling that of

[1] Millais searched the Shetlands for "voles," but, although such animals seemed to be known to the inhabitants, no specimens were forthcoming.

[2] Miller, *Ann. and Mag. Nat. Hist.*, May 1909, 420.

[3] Hinton, *ibid.*, July 1910, 35.

adults of (in this respect) less specialised Grass Mice, such as *M. hirtus;* the inter-parietal is short and broad, the coronal suture widely though deeply emarginates the parietals, and the squamosals are widely separated anteriorly in the hinder part of the inter-orbital region (Fig. 72, 1 and 1*a*). As the muscles become stronger with age, the faint ridges, which low down on each side of the skull mark the origin of the temporal fascia, become more salient and gradually ascend so that the distance between them is steadily diminished. Finally, the growth of the anterior portions of the muscles causes the ridges to meet and fuse into a sharp inter-orbital crest in adults, just as in the *agrestis* group; the anterior parts of the squamosals are stimulated to grow inwards and upwards upon the sides of the frontals until in the most advanced forms only the inter-orbital crest separates the right bone from the left; the post-orbital crests of the squamosals become more prominent, and each tends to develop an antero-external process. Under the same stimulus the parietals more extensively overlap the frontals; consequently the coronal suture and posterior processes of the frontals are reduced to a narrow notch and narrow tongues respectively (Fig. 72, 2 and 2*a*, and dimensions *a*, *b*, and 3 of table at p. 462). The growth of the posterior portions of the muscles causes the supra-tympanic parts of the squamosals to encroach upon the region occupied in the young by the lateral parts of the inter-parietal; the latter is therefore laterally reduced, and its growth becomes almost exclusively longitudinal; its greater portion is situated between the temporal ridges, and it acquires in the adults of *o. orcadensis* and *o. ronaldshaiensis* a highly characteristic pentagonal outline; the lateral processes of the supra-occipital gradually increase in saliency and the supra-tympanic fossæ, from which the hinder portions of the muscles arise,

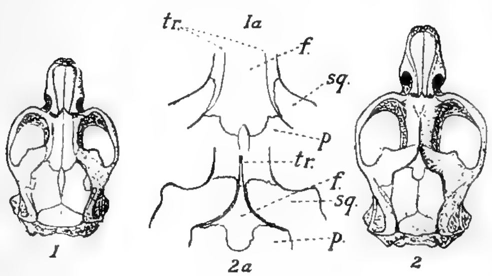


FIG. 72.—DORSAL VIEWS OF SKULLS OF *Microtus orcadensis.*

1. *M. o. orcadensis*, juv. (natural size); 1*a*, fore part of brain-case × 2. 2. *M. o. sandayensis*, adult; 2*a*, fore part of brain-case × 2; *f.* frontals; *sq.* squamosal; *p.* parietal; *tr.* temporal ridge. (Drawn by M. A. C. Hinton.)

are greatly enlarged (Fig. 72 and dimensions 8, 9, and 9-8 of table at p. 462).

The pleistocene *M. corneri* occupies a somewhat central position between *M. sarnius* and *M. orcadensis*, but it is on the whole, as might have been expected, more primitive than either. The incisors are straightened and protruding, the cheek-teeth of normal *arvalis* pattern, but light and short; the short nasals terminate roundly behind, the diastema is long, the posterior palatal septum grooved. The zygomata are narrow, the jugals heavy with boldly convex upper borders. The brain-case is long and narrow, the occiput intermediate in depth between *o. orcadensis* and *o. sandayensis*, the temporal ridges fuse into a low but sharp inter-orbital crest, the post-orbital crest of the squamosals is weak, though long, the inter-parietal, coronal suture and posterior frontal processes are entirely unmodified in the adult, retaining to the full the form seen in young *orcadensis*; anteriorly, however, the squamosals encroach upon the frontals, the distance between the right and left bones being no greater in adults than in adult *o. orcadensis*.

The Guernsey *M. sarnius* has an external appearance which recalls *M. agrestis*. In its cranium it is more specialised than *M. corneri*, except only in one respect, the wide anterior separation of the squamosals. The rather short nasals are cleft behind; the median septum of the hinder palate has no ventral groove.

M. orcadensis stands considerably higher than either *M. corneri* or *M. sarnius*. Owing to the richness of colour and length of the fur, the external appearance of its less modified southern sub-species is not very different from that of some of the Hebridean forms of *agrestis*; in its northern races, *westræ* and *sandayensis*, the colours tend to become pallid. The temporal muscles are throughout considerably stronger than in either of its allies, and in the transition from youth to age exert a much more powerful influence upon the form of the skull. In *ronaldshaiensis* and *orcadensis* the posterior portions of the muscles appear to be more powerful than the anterior; accordingly in these forms the modification of the inter-parietal is more profound (in adults) than elsewhere. The post-orbital crests are relatively weak, the occiput deep. The upper borders

of the jugals are boldly convex, and m_1 has a deep fourth outer fold. In *sandayensis* the anterior portions of the muscles are predominant, and therefore the changes in the fore part of the brain-case attain their culmination. On the other hand, the posterior portions are weaker than in *orcadensis* and the interparietal is less reduced. The occiput is depressed; the jugal convexities have disappeared so that these bones are slender; and the fourth outer fold of m_1 is obsolete. The modifications of the jugals and m_1 seen in the group are correlated by Hinton with the differential development of the two portions of the temporal muscles. The sub-species *rousaiensis* and *westræ* are intermediate between *orcadensis* and *sandayensis; rousaiensis,* on the whole, is nearer *orcadensis,* while *westræ* in some respects approaches *sandayensis,* as will be appreciated from the descriptions on pp. 458-61.

Miller points out that the distinctness of the Orkney Grass Mice amongst themselves appears to bear a direct relation to the depth of the channels between the islands, and therefore presumably to the length of time during which the colonies have been isolated. *M. o. ronaldshaiensis, orcadensis,* and *rousaiensis* inhabit islands separated by 6 to 8 fathoms of water, and they agree in external appearance; *westræ* and *sandayensis* with their more pallid coloration are cut off from the three southern forms by 17 to 20 fathoms, and are separated from each other by a 10 to 12 fathom strait.

Origin:—The *orcadensis* group appears to have arrived in south-eastern England in late pleistocene times, probably from France by way of the Channel Islands, which explains its absence from Skandinavia. It spread northward through Britain, becoming specialised as it dispersed, and eventually reached the Orkney district which was then part of the mainland; later, on the severance of the Orkneys from the mainland, portions, probably the northern first, became detached as separate islands. In these segregation has played its part, and differentiation of sub-species has been the result. At the time the group reached Scotland the Hebrides were apparently already separated from the mainland, for we have no evidence of the presence upon them at any time of a Grass Mouse of the present type. Hinton suggests to me that on the mainland

histories of very many others, which were formerly little known, have been fully elucidated, while, speaking generally, an immense increase in our knowledge on such important subjects as Migration, Distribution, Habits, Nidification, Plumages, has accrued: And lastly, a new and important branch of study has been instituted —namely, the recognition of the various Racial Forms or Subspecies exhibited by certain birds in the British Islands, on the Continent, and elsewhere.

A great advance has also been made towards a more satisfactory system of classification of the Aves—always a difficult subject—and this necessitates departures from the older views.

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It should be remarked that while it is not intended to go fully into Synonomy, yet, where changes of nomenclature have been necessary in order to conform with the Law of Priority—the only method by which complete uniformity in nomenclature can ultimately be attained—the names used in the Fourth Edition of Yarrell's "British Birds" and in Saunders' "Manual," and the Trinomial Names of the British Racial Forms, and of those occurring in Britain as visitors from the Continent, will be quoted, as will also the Original Name under which the species was described.

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BY

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THE publication of Yarrell's "History of British Birds" was commenced in 1837 and completed in 1843. Its outstanding merits were at once recognised, and a Second Edition was called for in 1845, followed by a third in 1856.

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In the year 1871 a Fourth Edition was begun, under the masterly editorship of Professor Newton—the greatest British ornithologist of all time. Unfortunately Professor Newton's official engagements at the University of Cambridge only allowed him to complete the first two volumes; and in 1882 Mr Howard Saunders was selected to edit the remaining volumes, a task which he successfully accomplished to the entire satisfaction of ornithologists in 1885.

The many excellences of this last edition advanced the work more than ever in the public and in scientific favour. To its stimulating influence is to be mainly attributed the marvellous and unprecedented activity which has resulted in those extraordinary advances made in all branches of British ornithology during recent years—advances which have rendered it essential that a new work based upon this classical and comprehensive foundation should be issued.

During the period alluded to, a considerable number of new and interesting species have been added to our avifauna. The

[Continued on Page 3 of Cover

CONTENTS OF PART XVI.

The English local names have been revised in part by Mr W. W. Skeat, M.A. (assisted by the late Professor W. W. Skeat), and in part by Mr C. M. Drennan, M.A. Lond., late Scholar Emm. Coll. Camb.; the Celtic and Gaelic names by Dr E. S. Quiggin, M.A., Ph.D., Fellow and Lecturer in Modern Languages and Celtic of Gonville and Caius College, Cambridge; while a list of Scottish Gaelic names has been supplied by Mr C. H. Alston. Much information has been taken from Mr G. S. Miller's recently published "Catalogue of the Mammals of Western Europe," the use of the MS. and proofs of which before publication was kindly permitted by the Trustees of the British Museum of Natural History.

ILLUSTRATIONS

FULL-PAGE (*Coloured and Black and White*).

FIGURES IN TEXT.

the group became extinct through unsuccessful competition with *M. agrestis neglectus*, just as the latter succumbed in the southern and lowland districts before the advance of *M. hirtus*. The persistence of *M. sarnius* in an island far to the south shows that these mice owe their survival to freedom from competition in islands rather than to any other factor; elsewhere they have probably succumbed to such competition, helped by the attacks of carnivora, from which large palatable mice inhabiting shallow burrows can only escape in the presence of moderately deep snow.

THE ORKNEY GRASS MOUSE.

MICROTUS ORCADENSIS, Millais.

1805. MUS AGRESTIS (species), George Barry, *History of the Orkney Islands*, ed. i., 314; ed. ii., 320, 1808 (part); Low, *Fauna Orcadensis*, 1813, 25 (part); T. E. Buckley, *Trans. Nat. Hist. Soc.*, Glasgow, i., 49, 1883-86 (part).

Local names and terminology:—*Cuttick* or *puttick* (Millais); *vole-mouse* of Barry, 1805 (see under *History*), a name which seems to have been the source of the term "vole," as already discussed above on pp. 398 and 443 (see also Edmonston's *Etymological Glossary of the Shetland and Orkney Dialect*, 1866).

Distribution:—This mouse is confined to the Orkneys, where it is known from all the bigger islands except, perhaps, the rocky Hoy[1]; it is abundant in parts of South Ronaldshay, Pomona, Shapinshay, Rousay, Westray, and Sanday.

History:—This mouse was first mentioned by Barry, minister of Shapinshay, in 1805:—"The Short-tailed Field Mouse (*Mus agrestis*, Lin. Syst.), which with us has the name of the *vole mouse*, is very often found in marshy grounds that are covered with moss and short heath, in which it makes roads or tracks of about 3 inches in breadth, and sometimes miles in length, much worn by continual treading, and warped into a thousand different directions" (in ed. ii., 1808; ed. i. not seen).

Subsequently to Barry's time the mouse appears to have been known to many naturalists, none of whom examined it critically. Baikie and Heddle appear to have confounded it with the Water Rat, other writers with *M. agrestis*. In August 1886 Millais's attention was attracted by some individuals which he observed in Pomona, but

[1] Note that Baikie and Heddle (*Addendum*, 97) record the capture of two specimens of *Mus amphibius* in the burn by Rackwick, in Hoy, by M. F. Heddle in September 1844.

he obtained no specimens until August 1887, and none were preserved until September 1898; his description of *orcadensis* did not appear until July 1904.

Description:—This is a large mouse with the hind foot 17 to 20, and the condylo-basal length of the skull in adults, 27·5 to 30 mm. The southern races are dark **coloured**, the northern relatively pallid. The **cheek-teeth** are essentially as in the *arvalis* group of continental Europe; m^2 lacking the small third inner angle of the *agrestis* group; m_1, except in the most modified sub-species, having a deep fourth outer fold; and m_3 the third outer angle distinct but small. In addition to the, in some forms, strikingly narrow, subquadrate or pentagonal inter-parietal, and the other characters correlated with the exceptionally powerful temporal muscles (discussed above on p. 453), the **skull** differs from that of *M. agrestis* in its slightly greater breadth (zygomatic breadth equals 60-61 per cent. of condylo-basal length); relatively longer and anteriorly more gradually expanded nasals; slightly longer diastema; shorter and lighter cheek-teeth; and smaller, less rounded and more angular auditory bullæ. The nasals are cleft behind by a small frontal process, and the posterior palatal septum bears a well-marked ventral groove (Fig. 73, D). From that of the continental *M. arvalis*, the skull differs in its greater size and zygomatic breadth; relatively smaller bullæ; narrower palate; and lighter cheek-teeth; in addition, adults are remarkable for the far greater perfection of that cranial specialisation which results from the increased strength of the temporal muscles.

Moults take place twice a year, at the end of May and in August and September. They may be gradual, the new hairs replacing the old as they drop out; but sometimes the long black hairs and the light tips of the shorter hairs of the back are shed in a mass, leaving the animal with only the dusky bases of its fur in a condition which has been mistaken for melanism.

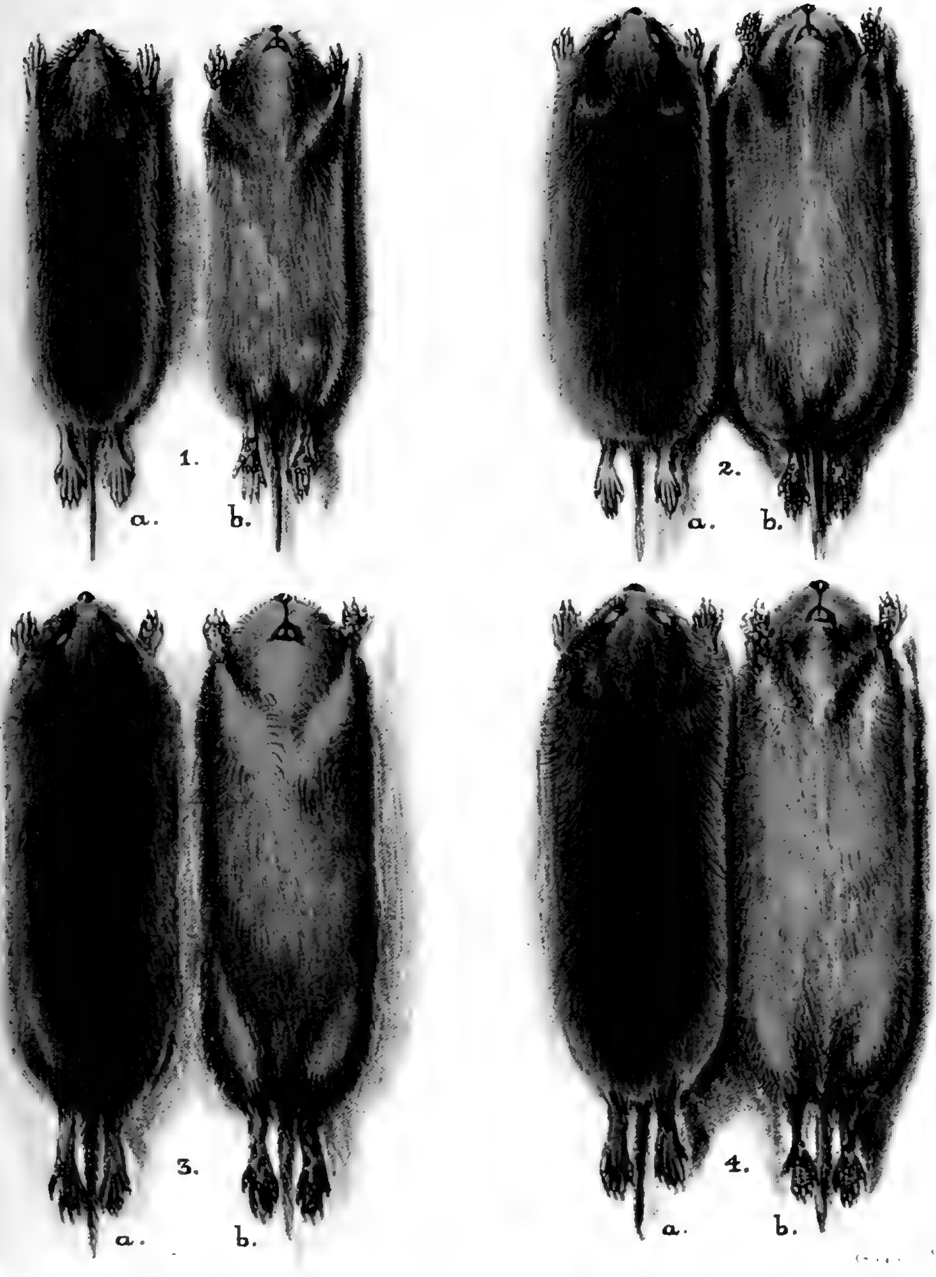
Further special characters are noted under the sub-species which are as follows, commencing with the most primitive and ending with the most modified:—

(1) *M. orcadensis ronaldshaiensis*, Hinton.

1913. MICROTUS ORCADENSIS RONALDSHAIENSIS, M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, November 1913, 457; described from South Ronaldshay, Orkneys; type, an adult male, No. 7.11.16.1 of British Museum collection.

Distribution:—South Ronaldshay, Orkneys.

Description:—This sub-species cannot be distinguished externally from *M. o. orcadensis*, but differs in the following cranial characters:—The brain-case is longer and narrower; the squamosals are slightly more widely separated anteriorly, their post-orbital crests less salient



BRITISH *Microtinæ* (SKINS);
(1) *Microtus hirtus*; (2) *M. agrestis neglectus*; (3) *M. orcadensis*; (4) *M. agrestis exsul.*

and without any antero-external process; the inter-parietal is slightly more reduced, the supra-tympanic fossæ being much more extensive laterally. The jugals and m_1 are as in *o. orcadensis.* For dimensions and cranial measurements, see tables at pp. 462-3.

(2) *M. orcadensis orcadensis* (Millais).

1904. MICROTUS ORCADENSIS, J. G. Millais, *Zoologist*, July, 244; described from Sandwick, Pomona, Orkneys; type, an old male, No. 4.6.21.1 of British Museum collection; also, *Mammals of Great Britain and Ireland*, 1905, ii., 278, pl. 47; Eagle Clarke and Bradley, *Ann. Scott. Nat. Hist.*, 1905, 1-8; Forsyth Major, *Ann. and Mag. Nat. Hist.*, March 1905, 323; Pycraft, British Museum *Guide to British Vertebrates;* Trouessart; Miller (*Catalogue*).

Distribution:—Pomona and possibly Shapinshay, Orkneys.

Description:—In this sub-species the **colour** of the upper side is rich, dark brown, near "clove brown," overlaid with "ochraceous buff," and passing without sensible line of demarcation into the clear, bright ochraceous buff of the under-side, the latter slightly obscured, especially on the chin and throat, by the dusky hair-bases showing through.

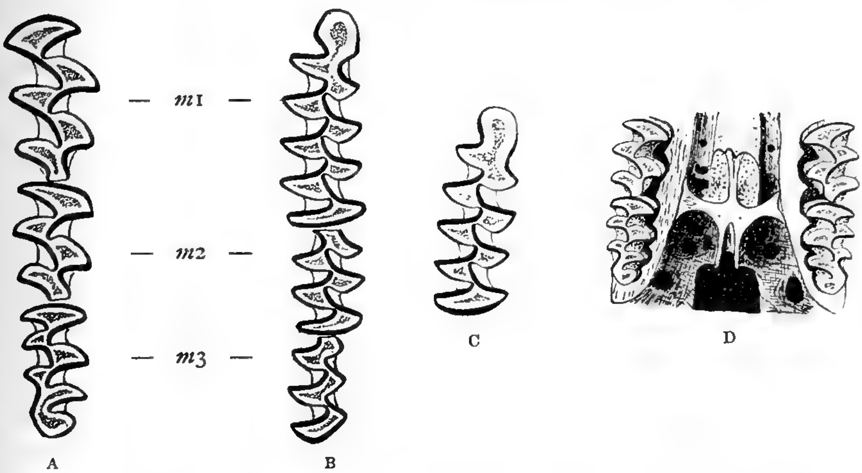


FIG. 73.—RIGHT CHEEK-TEETH OF *Microtus orcadensis orcadensis* (A, upper; B, lower); (C), RIGHT m_1 OF *M. o. sandayensis* (A, B, and C 9 times life size); (D), posterior palate of *M. o. sandayensis* (5 times life size). (Drawn by M. A. C. Hinton.)

The upper surface of the tail is blackish; the under surface, with the feet, light grey, tinged with ochraceous buff. The tail may have the tip white (Millais). The soft first coat of the **young** is duller than in adults, and at first always lacks the rufous tints on the belly; later, the belly may become rufous before the back gains the adult pelage (Kinnear).

The **skull** when adult has the brain-case short and broad; the occiput not depressed (median depth equals 55-56 per cent. of greatest

width across the lateral processes of the supra-occipital); the inter-parietal pentagonal and very narrow; the inter-orbital region comparatively broad; the squamosals separated anteriorly by 1·4 mm., their post-orbital crests moderate with feeble antero-external processes; the jugals with well-marked central expansions, their upper borders boldly convex; m_1 each with a deep fourth outer infold. For external and cranial dimensions, see tables at pp. 462-3.

(3) *M. orcadensis rousaiensis*, Hinton.

1913. M. O. ROUSAIENSIS, M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, November 1913, 460; described from Rousay, Orkneys; type, an adult male, No. 12.7.5.7 of British Museum collection.

Distribution:—Rousay, Orkneys.

Description:—This sub-species is externally indistinguishable from *o. orcadensis*, but has a **skull** intermediate in character between the latter and *o. sandayensis.*

The brain-case is short and broad, as in *o. orcadensis;* the occiput occasionally depressed; the inter-parietal and the supra-tympanic fossæ nearly as in *o. orcadensis;* the squamosals separated anteriorly by 1·0 mm., their post-orbital crests and processes intermediate in saliency between those of *o. sandayensis* and *o. orcadensis;* the degree of inter-orbital constriction is also intermediate; the jugals are always slender, as in *o. sandayensis; m_1* always has a deep fourth outer infold, as in *o. orcadensis.* For external and cranial dimensions, see tables, pp. 462-4.

(4) *M. orcadensis westræ* (Miller).

1908. MICROTUS SANDAYENSIS WESTRÆ, G. S. Miller, *Ann. and Mag. Nat. Hist.*, February, 199; described from Pierowall, Westray, Orkneys; type, a sub-adult male, No. 8.1.2.1 of British Museum collection; Trouessart; Miller (*Catalogue*).

1913. MICROTUS ORCADENSIS WESTRÆ, M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, November 1913, 460.

Distribution:—Westray, Orkneys.

Description:—The colour is similar to that of *o. sandayensis*, but the dark shading of the longer hairs is more noticeable, and the tips of the underfur are nearer to dull ochraceous buff. The under-side is coloured like that of *M. o. orcadensis*, but is paler, the dusky bases of the hairs taking a more prominent part in the general effect. The tail is more densely sprinkled with black hairs than in *o. sandayensis.*

The **skull** of the sub-adult type has the brain-case short and broad; the occiput is much depressed, more than in any specimen of *o. sandayensis* examined; the inter-parietal nearly as reduced as in *o. orcadensis;* the lateral processes of the supra-occipital very salient; the supra-tympanic fossæ nearly as extensive as in *o. ronaldshaiensis;* the inter-orbital region relatively broad; the squamosals not more closely

approximated anteriorly than in *o. orcadensis;* the jugals slender; m_1 with the fourth outer fold sometimes as deep as in *o. orcadensis*, sometimes obsolete, as in *o. sandayensis.* For external and cranial measurements, see tables at pp. 462-4.

(5) *M. orcadensis sandayensis*, Millais.

1905. MICROTUS ORCADENSIS SANDAYENSIS, J. G. Millais, *Mammals of Great Britain and Ireland*, ii., 280; described from specimens procured by George Sim, from Sanday, Orkneys; type, an immature male, No. 5.11.22.3 of British Museum collection; Hinton, *Ann. and Mag. Nat. Hist.*, November 1913, 460.

1908. MICROTUS SANDAYENSIS, G. S. Miller, *Ann. and Mag. Nat. Hist.*, February, 199; Pycraft, British Museum *Guide to British Vertebrates;* Trouessart.

1912. MICROTUS SANDAYENSIS SANDAYENSIS, G. S. Miller, *Catalogue of the Mammals of Western Europe*, 697.

Distribution:—Sanday, Orkneys.

Description:—In size this sub-species about equals *o. orcadensis*, from which it is readily distinguishable by its lighter **colour**. The upper side is nearer "hair-brown" than "mummy-brown," the tips of the underfur being between "cream-buff" and "ecru-drab." The tail is greyish white, sprinkled with blackish hairs along the median upper surface.

The **skull** differs from that of *o. orcadensis* in its more depressed brain-case (median occipital depth equals 50-52 per cent. of greatest width across lateral processes of supra-occipital); less reduced inter-parietal and smaller supra-tympanic fossæ; more constricted inter-orbital region, in which the squamosals are separated merely by the inter-orbital crest (average distance between them 0·7 mm.), their post-orbital crests salient (with well-marked antero-external processes); slender jugals; relatively slightly longer nasals and diastema; and slightly shorter cheek-teeth.

In the **teeth**, m_1 has the fourth outer fold obsolete (Fig. 73).

For external and cranial measurements, see tables at pp. 462-4.

The well-beaten runs and thoroughfares of the Orkney Grass Mouse are often conspicuous for long distances in heather or other vegetation in rough fields or hills; they are either exposed, or form tunnels where vegetation is dense. Their diameter is from 2 to 2.25 inches, or a little more than the extreme spread of the animal's whiskers,[1] and they may be found in either dry or wet ground, in the latter case sometimes tunnelling through saturated sphagnum by pools of water.

[1] J. G. Millais, *Zoologist*, 1904, 244, and *Mammals of Great Britain and Ireland*, ii.; Robert Godfrey, *Ann. Scott. Nat. Hist.*, 1905, 195; see also N. B. Kinnear, *Journ. cit.*, 241; for other references see *Synonymy*.

CRANIAL DIMENSIONS OF *M. ORCADENSIS* AND ALLIES:—*

	Microtus orcadensis.												*M. sarnius* (type).	*M. corneri* (type).
	ronaldshaiensis.	*orcadensis.*		*rousaiensis.*				*westræ.*	*sandayensis.*					
	Adult (type).	Juv., average of 4.	Adult (type).	Sub-adult.	Adult female.	Adult male, average of 3.	Largest male (type).	Sub-adult (type).	Juv., average of 2.	Sub-adult, average of 2.	Adult, average of 12.	Largest adult (male).		
1. Condylo-basal length	29·0	24·7	28·*ca*	27·1	27·7	28·5	28·9	27·2	25·5	27·0	28·7	30·1	27·6	28·8
2. Zygomatic breadth	17·6	14·6	17·2	16·5	16·6	17·2	17·6	16·2	15·25	16·4	17·4	17·8	16·1	16·5
3. Inter-orbital breadth (least)	3·8	3·85	3·8	4·0	3·5	3·66	3·7	3·8	3·65	3·65	3·35	3·4	3·7	3·6
6. Width of brain-case between ear and zygoma	11·1	10·9	11·0	11·3	10·3	11·1	11·2	11·0	10·85	11·15	11·34	11·5	10·8	11·1
9. Occipital breadth (across lateral processes of supra-occipital)	12·9	11·27	12·3	12·5	11·9	12·53	12·7	13·0	11·3	11·9	12·6	13·2	11·7	13·0
10. Occipital depth (median)	7·2	6·2	..	6·4	6·2	6·9	7·0	6·4	6·1	6·25	6·46	6·9	6·3	7·0
15. Nasal length	9·2	7·0	8·6	8·3	8·8	8·8	8·9	7·8	7·8	8·6	9·15	9·4	7·8	7·9
17. Diastema	8·7	7·05	8·2	8·0	8·2	8·53	8·9	7·8	7·4	7·85	8·7	9·3	7·9	9·1
18. Maxillary cheek-teeth, alveolar length	6·7	6·15	6·6	6·5	6·5	6·7	6·7	6·9	6·05	6·25	6·63	6·7	6·8	6·2
REDUCTIONS: if 1. *Condylo-basal length* = 100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2. =	60·8	59·0	61·3	61·0	59·8	60·3	60·9	59·4	59·8	60·8	60·6	59·0	58·3	57·8
6. =	38·3	44·1	39·2	41·7	37·1	39·0	38·7	40·3	42·5	41·3	39·4	38·2	39·1	38·6
15. =	31·7	28·3	30·7	30·6	31·7	30·9	30·8	28·6	30·6	31·9	31·9	31·2	28·2	27·4
17. =	30·0	28·5	29·2	29·5	29·6	30·0	30·8	28·6	29 0	29·1	30·3	30·9	28·6	31·6
18. =	23·1	24·9	23·6	24·0	23·4	23·5	23·2	25·3	23·7	23·1	23·1	22·2	24·6	21·6
REDUCTIONS: if 6. *Cranial width* = 100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
3. =	34·2	35·2	34·6	35·4	34·0	33·0	33·1	34·6	33·7	32·7	29·5	29·5	34·3	32·4
a. Least distance between right and left squamosals in front =	18·0	31·7	12·7	21·2	8·7	9·3	7·1	13·6	18·9	19·3	6·4	5·2	29·6	14·4
b. Width of posterior process of frontals =	13·5	22·7	19·1	22·1	12·6	10·8	8·9	20·0	19·3	18·4	12·7	15·6	24·1	32·4
8. Least distance between temporal ridges in the neighbourhood of inter-parietal =	40·5	54·6	42·8	47·8	42·7	44·4	42·0	44·6	53·1	53·8	50·2	52·1	57·4	58·5
9. =	116	103·5	112	110·5	115·5	113	113·5	118	104·5	107	111	115	108·5	117
9. less 8. =	75·5	48·9	69·2	62·7	72·8	68·6	71·5	73·4	51·4	53·2	60·8	62·9	51·1	58·5
REDUCTION: if 9. *Occipital width* = 100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
10. =	55·8	55·0	..	51·2	52·1	55·0	55·1	49·2	54·0	52·5	51·3	52·2	53·8	53·8
Length of mandible	18·6	16·4	17·5	17·4	17·8	18·56	18·8	16·9	16·1	17·2	18·2	18·5	17·6	..
Length of mandibular cheek-teeth (alveolar)	6·7	6 1	6·5	6·1	6·4	6·7	6·7	6·6	5·95	6·1	6·6	6·7	6·8	..

* These measurements (in millimetres) and calculations were made by Hinton, and have been extracted from his manuscript; the numerals or letters in the left-hand column are those by which the various positions are numbered or marked in the original tables, and they are given here to facilitate comparison in the future, when Hinton's work is published.

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
M. o. ronaldshaiensis, South Ronaldshay—					
1. Male, 23rd Oct. 1907 (type of sub-species)	126	41	19	11·5	..
2. Female, 31st Oct. 1907 (Royal Scottish Museum)	128	40	19	13	..
3. Female, 31st Oct. 1907 (Royal Scottish Museum, W. Eagle Clarke) . .	127	40	19	13	..
SPECIMENS CAUGHT AND MEASURED BY N. B. KINNEAR, AT STROMNESS, POMONA.					
MALES:—					
M. o. orcadensis—					
1. 24th May 1905	111·5	40	19	11	49·92
2. 24th ,, ...	115	39	19·5	12	46·67
3. 24th ,, ...	100	35	18	11	46 65
4. 26th ,, ...	113	39·5	19	12	62·22
5. 26th ,, ...	109	32·5	18	12	40·70
6. 26th ,, ...	109	36	18·5	11·5	38·26
7. 26th ,, ...	121	36	19·5	13·5	57·60
8. 26th ,, ...	116	38	19·5	12	49·53
9. 27th ,, ...	119	40	18·5	12	49·79
10. 27th ,, ...	122	40	19·5	12·5	55·68
11. 27th ,, ...	125	44	20	12	57 21
12. 28th ,, ...	119·5	38	18	13	56·32
13. 28th ,, ...	112	40	19	12·5	50·88
14. 28th ,, ...	120	38	17	12·5	56·38
15. 29th ,, ...	116	38·5	19	11·5	56·32
16. 29th ,, ...	121	40	19	12	58·43
17. 29th ,, ...	116	35	18	12	61·48
18. 29th ,, ...	113	36	20	11·5	46·86
19. 30th ,, ...	121	42	19	11	62·08
20. 30th ,, ...	120	38·5	18	12	46 08
21. 30th ,, ...	120	36	18·5	12·5	53·76
22. 30th ,, ...	124	40	20	11·5	57·79
Average of 22 males	116·5	38·27	18·8	11·97	57·31
FEMALES:—					
M. o. orcadensis—					
1. 24th May 1905	107	39	18	11·5	48
2. 24th ,, ...	105	33	19	11	46·08
3. 25th ,, ...	113	35	18·5	11	43·52
4. 25th ,, ...	120	35	19	11·5	46·27
5. 26th ,, ...	114	38	18·5	11·5	48·02
6. 26th ,, ...	100	32	18	12	40·06
7. 26th ,, ...	120·5	35	18	12·5	51·20
8. 26th ,, ...	125	40	19	12	59·71
9. 27th ,, ...	105	36	18·5	12	34·11
10. 27th ,, ...	102	38·5	17	11	48·06
11. 28th ,, ...	123	42	18·5	12	63·04
12. 29th ,, ...	109·5	34	18	11	42·24
13. 29th ,, ...	103	31·5	18	11·5	43·26
14. 30th ,, ...	121	41	20	13	58 50
15. 30th ,, ...	116	37	19	13	51·84
16. 30th ,, ...	114	42·5	19	12	46·08
Average of 16 females *	112·37	37·15	18·4	11·8	46·08

* This series may be taken as consisting only of individuals born before the current season. The influence of immature specimens on the average in October, and the general subsequent increase in size (*cf.* Shrews, above, p. 92) is shown in the following table, which is also based on measurements supplied by Kinnear:—

ITEMS.	9th to 14th Oct. (12)	7th Nov. (16)	17th Nov. (8)	Dec. 1905. (9)
Maximum	105 (female)	126 (female)	126 (male)	120 (female)
Approximate average . .	93·8	102·6	106·6	109·5
Minimum	83·5 (female)	92 (female)	94 (female)	100 (female)

DIMENSIONS IN MILLIMETRES (*continued*):—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
M. o. rousaiensis—					
Four males caught and measured by W. R. Ogilvie-Grant, on Rousay, 13th and 14th June 1912.					
1. . . . . (Type)	135	36	18	12	..
2.	133	41	19·5	12	..
3.	127	38·5	18	13	..
4.	127	40	16·5	11	..
Two caught and measured by W. Cowan, 25th August 1904.					
5. Male	126	45	20	12·5	..
6. Female	120	35	18	11	..
M. o. westræ—					
1. Male, 5th April 1906, J. Edgar, per N. B. Kinnear (type of sub-species) .	108	34	18	10·5	..
2. Male, G. S. Miller	115	42	18	11	..
3. Female, G. S. Miller	108	38	17	11	..
MALES:—					
M. o. sandayensis—					
Two caught and measured by W. C. Wallace (per N. B. Kinnear).					
1. 3rd Jan. 1906	102	33	18	10·5	..
2. 22nd ,, ...	117	37·5	19	11	..
Six caught and measured by W. R. Ogilvie-Grant.					
3. 8th June 1912	119	38	17	13·5	..
4. 23rd ,, ...	131	42	18	13	..
5. 24th ,, ...	125	43	18·5	11·5	..
6. 27th ,, ...	118	39	17·5	11	..
7. 27th ,, ...	116	38	17 5	12	..
8. 27th ,, ...	115	40	18	11·5	..
Approximate average of 8 males . .	118	38·8	17·9	11·8	..
FEMALES:—					
M. o. sandayensis—					
Nine caught and measured by W. C. Wallace (per N. B. Kinnear).					
1. 3rd Jan. 1906	110	38·5	18	10·5	..
2. 3rd ,, ...	104	35·5	18·5	10·5	..
3. 3rd ,, ...	111	42	18	11·5	..
4. 3rd ,, (immature) . .	95	32	17	10·5	..
5. 22nd ,, ...	100	35	16 5	10	..
6. 22nd ,, ...	100	35	18	10	..
7. 22nd ,, ...	111	35	18 5	11	..
8. 22nd ,, ...	103	35	18	10	..
9. 22nd ,, ...	96	35	18	10	..
Four caught and measured by W. R. Ogilvie-Grant, 6 fœtuses.					
10. 9th June 1912	120	35	18	13	..
11. 27th ,, ...	122	39	18	12·5	..
12. 28th ,, ...	118	34	17	12	..
13. 28th ,, ...	98	33	17	11·5	..
Approximate average of 10 adult females, omitting (as immature) Nos. 4, 9, and 13	110	36·4	17·8	11·2	..

The mice are also found on sandy ground near the sea-shore, as on Sanday. They sometimes enter cultivated fields to feed on the crops, and numbers may then be killed when the hay is cut in August.

Nests of dry grass and roots, having a greatest diameter of from 5 to 8 inches, are placed in rounded chambers in the centres of small mounds. They are never at the end of a run, but are approached by a network of paths suggestive of a mole's "fortress."

The mice may be seen in their runs all day, but that does not imply that they are not also active in the night.[1] They swim well, and Mr Millais states that if pursued they will plunge into a pool rather than go round by land; one which he released in a pond dived under the surface.

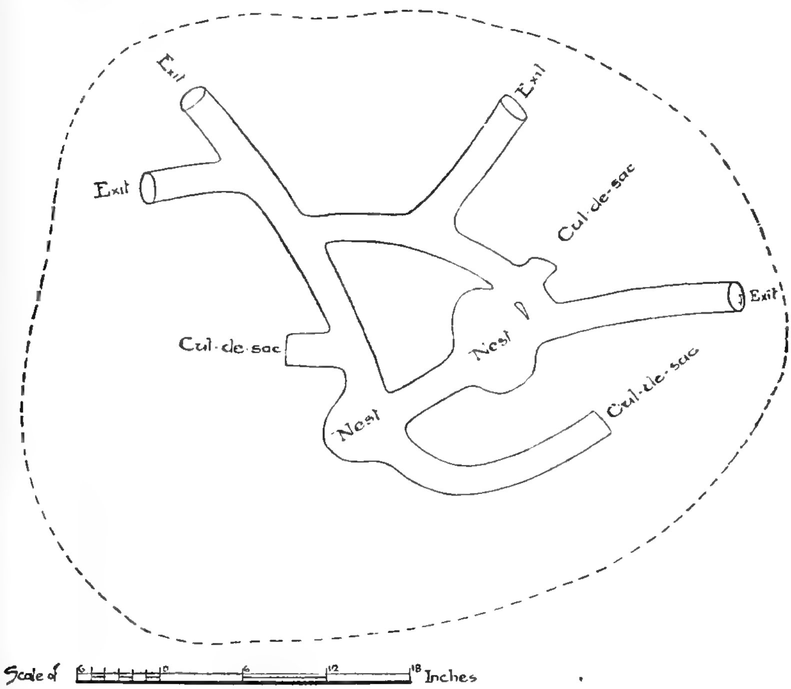


FIG. 74.—PLAN OF NESTS OF ORKNEY VOLE. (The dotted line represents the base of the mound.)

They do not seem to be very prolific nor to have a long sexual season, and for this reason, perhaps, no "plagues" are known to have occurred in the Orkneys. Mr Millais reports that the first litters appear in April, and he has seen half-grown young at the end of September. But Mr Kinnear found no young at the end of May, except one about a quarter grown.

[1] Ogilvie-Grant caught one at 10.30 P.M.

At that time, of sixteen females trapped, several were pregnant with from two to six fœtuses.[1] Others taken by Mr Godfrey on 8th and 9th August contained fœtuses "the size of peas." Mr Robert Drane[2] has bred these mice in confinement, and states that six received in August 1904 increased to sixteen by October. There was then a cessation of reproduction until 28th February 1905, when two of the females gave birth to litters of three and four young respectively. Mr Drane definitely ascertained that the period of gestation is, as in other species, twenty-one to twenty-two days (one instance). The young of one litter opened their eyes and emerged from the nest to nibble lettuce leaves on the 12th day. At eighteen days old they were independent of their mother, who still, however, exercised parental authority and drove them home peremptorily if she considered them in danger.

Mr Kinnear found the mice fond of the roots of a common rush,[3] to obtain which they burrow under the tufts. Mr W. R. Ogilvie-Grant took the Sanday form with baits of cheese and bulbs of yellow crocus. In captivity their favourite food is grass; next, carrots. Their intelligence appears to be intermediate between that of the Bank Mouse and the Common Grass Mouse, but reports of their amiability vary, no doubt according to the manner in which they were treated. They may bite if roughly handled, will attack fresh members of their own species when first introduced to their cage, and sometimes behave with great brutality amongst themselves.[4] Females with young must be isolated to protect the litter from the attacks of strange males.

Mr Millais found that his mice became inactive during cold weather.

Like other Grass Mice, the Orkney Mouse is very palatable. Every bird and beast seems to eat it, and dogs devour it greedily.[5]

[1] One contained two; three contained four; one contained six.

[2] *Field*, 18th March 1905, 465; also in Millais.

[3] Determined by W. Evans as *Juncus squarosa*.

[4] Drane, *op. cit.*

[5] T. E. Buckley, *op. cit. supra*, p. 49.

LOCALLY EXTINCT VOLES.

Microtus arvalis (Pallas, *Nov. Sp. Quadr. e. Glir. Ord.*, 78, 1778) differs from *M. agrestis* in its smaller size; broader, shorter, more depressed, and less angular brain-case; and in m^2 having only two instead of three salient angles on the inner side. Miller recognises four sub-species in western and central Europe, viz., *M. arvalis arvalis*, Pallas, known from Germany, Belgium, France, Switzerland, Austria-Hungary and northern Italy, characterised by its small size (hind foot, 15 to 17 mm.; condylo-basal length, 23 to 25 mm.) and normal skull; *M. a. meridianus* (Miller, *Ann. and Mag. Nat. Hist.*, February 1908, 197) from south-western France (Pyrenees), a slightly larger, more yellowish form (hind foot, 15.8 to 16.6 mm.; condylo-basal length about 25 mm.); *M. a. duplicatus* (Rörig and Börner, *Arb. aus d. Kais. Biol. Anstalt f. Land- u. Forstwirthschaft*, v., Heft ii., 73, 1905), from the Baltic coast of north-eastern Germany, a large pallid form with robust skull and deep brain-case (hind foot, 17 to 18.6 mm.; condylo-basal length, 25 to 25.5 mm.), and *M. a. levis* (Miller, *Ann. and Mag. Nat. Hist.*, February 1908, 197) from Rumania, southern Hungary, and north-eastern Italy, resembling *duplicatus* in its large size and pale coloration, but with the skull slender, the brain-case long, narrow, and smoothly rounded, and usually with relatively large auditory bullæ. Other nearly related forms carry the range of the species far to the east through Siberia and central Asia.

On several occasions fossils from various British deposits of late Pliocene and Pleistocene age have been determined as belonging to *M. arvalis* (*e.g.*, from fissures near Bath, Somerset, by Blackmore and Alston, *Proc. Zool. Soc.*, 1874, 468); but in most cases such records imply, because of the fragmentary nature of the material on which they are based, nothing more than the presence of a "vole" with an arvaloid, *i.e.* a normal dentition. Some rather well-preserved cranial fragments have been collected from the late Pleistocene of Ightham by Abbott, Corner, and others, and Hinton (*Proc. Geol. Assoc.*, xxi., 495) finds that these are "apparently identical" with *M. a. arvalis.*

Ightham probably marks the date of the arrival of the species in Britain, since no *arvalis*-like "vole" is represented among the many microtine fossils recovered from the Crayford brickearth, a deposit one stage older than that of Ightham.

Microtus anglicus (Hinton, *Ann. and Mag. Nat. Hist.*, July 1910, 36, first referred by Nehring to a little-known existing species, *M. gregalis*, Pallas) is a very remarkable species belonging to the highly specialised Asiatic group which Kastchenko calls *Stenocranius*. The skull is very long and narrow, with the long inter-orbital region greatly constricted and bearing a sharp median crest; the median septum of the hinder palate is long and thin. The upper cheek-teeth are similar to those of *M. arvalis*. m_1 (Fig. 75) is of peculiar form; it has the posterior loop and five closed triangles of normal *Microtus*, but the fourth outer angle (counting from behind) is reduced, and the fourth outer fold obsolete; the outer border of the anterior loop is long and straight, and the tooth has only three outer salient angles. m_3 has the third outer angle obsolete. The *Stenocranius* group is regarded by Hinton as an offshoot of the *arvalis* group, its cranial and dental peculiarities being apparently results of an increased development of the temporal muscles; this specialisation is similar in kind, though more intense in degree, to that described in the *orcadensis* group at p. 453. It is thus possible that instead of there being any specially close affinity between *M. anglicus* and the similarly modified forms of central Asia, the former may afford an instance of parallel evolution from a common arvaloid stock.

(1) (2)

FIG. 75.—(1) FOSSIL RIGHT m_1 OF *M. anglicus* of the late Pleistocene of England; (2) of *Microtus ratticeps* (K. and B.); Pleistocene of England; 8 times life size.

M. anglicus first appears in Britain in, and is perhaps the most characteristic element of, the late pleistocene fauna (Ightham), and it, or closely allied forms, had a wide range in western and central Europe. So far as is known, all such forms are now extinct in this region.

Microtus ratticeps (Keyserling and Blasius, *Mem. Acad. Imp. Sci. Nat., St Petersburg*, iv., 3, 333, 1841 (1845); described from

Wellikii-Ustjug, north central Russia) is a large, long-skulled mouse with relatively heavy teeth (condylo-basal length of skull to 30 mm., the condylo-basal length about twice the zygomatic breadth; hind foot 19 to 21); m_1 resembles that of *M. anglicus* in having only three outer salient angles, but the fourth outer angle is still more reduced and the third outer fold is shallow, so that there are only four closed triangles, the fifth opening more or less widely into the anterior loop (Fig. 75). m^3 has usually a small fourth outer angle; and m_3 has the third outer angle distinct though small.

M. ratticeps is found at the present time in northern Eurasia, from Skandinavia (in mountains and lowlands) to some point in Siberia, and south to Holland, northern Germany, and Hungary, although it has not yet been detected in Denmark (Winge, *Danmarks Pattedyr*, 78). It formerly lived in Britain, first appearing in the Clevedon Cave, Somersetshire (Middle Pleistocene), where it is accompanied only by *M. malei* and *C. nivalis*. In the "middle terrace" horizons of Crayford and Erith, and Fisherton, its remains are common and associated with those of lemmings and a pouched marmot (*Citellus*) in addition to those of *C. nivalis*. It is known also from many later pleistocene deposits, as Ightham, Forest of Dean Cave, Langwith Cave, Derbyshire, and "Dog Holes," Lancashire; in such horizons its remains are scarce and associated with those of *M. anglicus*, lemmings, *Citellus* and *Pika*, while *C. nivalis* is absent. The late pleistocene bones appear to be identical with those from individuals living in Holland and Germany. According to Hinton (*op. cit.*, 503), *M. ratticeps* reached this country with *Chionomys* from France during the later part of the "middle terrace" stage.

Microtus malei (Hinton, *Proc. Geol. Assoc.*, xx., 48, 1907, first referred to *Chionomys* and subsequently to *Microtus*, *Proc. Geol. Assoc.*, xxi., 494) is a "species with (typically) a rather generalised dental pattern such as that which probably characterised the ancestor of several species like *M. ratticeps* and *C. nivalis*," and the specimens from the Clevedon Cave upon which this species was originally based represent only its nivaloid variation. It is only known from the Middle Pleistocene of Britain, occurring in the Clevedon Cave,

Somersetshire, and in the later "middle terrace" deposits of the Thames at Crayford and Erith.

Remains of several small species of *Microtus* have been found in the late pliocene Forest Bed of Norfolk. In their dental characters these recall such existing forms as *M. arvalis* and *ratticeps*, or the pleistocene *anglicus*, but they all have peculiarities which show that they belong to extinct types which probably have little real connection with those of the late pleistocene or recent faunas of western Europe (Forsyth Major, *Proc. Zool. Soc.*, 18th February 1902, 107; Hinton, *Proc. Geol. Assoc.*, xxi., 490, 1910). One of these Forest Bed forms, *M. nivaloides* (Forsyth Major, *op. cit.*, 106, Fig. 19), may possibly be a forerunner of *Chionomys.*

The sub-genus **Chionomys** was formed by Miller (*Ann. and Mag. Nat. Hist.*, January 1908, 97; based on *Arvicola nivalis* of Martins, *Revue Zoologique* (Paris), 1843, xix., 87) for the mice usually known as the "Snow Voles," and formerly referred to a single species (*nivalis*). Miller now recognises three European species; these, or their allies, are found from the Pyrenees to Asia Minor and Transcaucasia, mostly in mountains. They have rather long tails, usually of whitish colour, full soft fur, and a very characteristic slaty-grey upper side. The skull has a broad, flat, rather smooth brain-case, wide inter-orbital region, inconspicuous temporal ridges, and the hinder palate sculptured in low relief with a broad median septum. m^3 has only two folds and three salient angles on either side; in m_1 the anterior loop is small, broad, and crescentic.


A B

FIG. 76.—*Chionomys nivalis:* A, left m_1; B, left m^3; crown view; 7½ times life size. (Drawn by M. A. C. Hinton.)

Chionomys has been identified from numerous continental deposits of Pleistocene age, as in Lombardy, and at Parignana, near Pisa, Italy (see Forsyth Major, *Atti. Soc. Sci. Nat. Ital.*, 1872, xv., 378); in the island of Palmaria, near Spezzia; in French Switzerland; in Bohemia and Moravia (Nehring, Woldrich).

In Britain, disregarding *M. nivaloides* of the Forest Bed

(which may also occur in the early middle terrace deposit at Grays Thurrock, Hinton), which cannot be referred to this sub-genus with any certainty, the later middle terrace deposits yield abundant remains of nivaloid voles. Large series of lower jaws from the Clevedon Cave, and from the brick-earth of Crayford and Erith, have been studied by Hinton (*Proc. Geol. Assoc.*, 1907, 39, and 1910, 493), who cannot separate them in the absence of skulls from those of recent members of the group.

The former wide distribution (in the lowland districts of western Europe) of this group, usually associated with high altitudes and perpetual snow, has contributed to the view that these districts were afflicted during the pleistocene period with a climate much more severe than that which they now enjoy. Hinton combats this view, pointing out that *Chionomys* is a southern group not now occurring north of the Alps and at no time known further north than Norfolk or southern Germany, and he suggests that it reached Britain from the south through France. He regards it as an ancient lowland group which has been forced to recede to mountain fastnesses before the competition of newer and stronger immigrants, and thinks that it owes its survival to the present epoch solely to the fact that it has been able to colonise the mountains, where it finds security from competitors, enemies, and frosts, beneath the Alpine snows, in accordance with the principle already advocated by Bulman (*Nat. Science*, iii., October 1893, 261-266) and by Scharff (*European Animals*, chaps. vii., viii., and ix., and pp. 54 and 56).

Hinton's argument has been very remarkably substantiated by Mottaz's rediscovery (Miller, *Ann. and Mag. Nat. Hist.*, January 1908, 97; Hinton, *Sci. Proc. R. Dublin Soc.*, N.S., xii., 264) of *M. lebrunii lebrunii* on hot plains near the French shores of the Mediterranean at Nîmes. Glacial conditions are thus shown to be anything but indispensable to the sub-genus.

The genus **Pitymys** (MacMurtie, American edition of Cuvier's *Régne Animal*, i., 134, 1831, renaming the preoccupied *Psammomys* of Le Conte, 1830, based on *Psammomys pinetorum*, Le Conte, 1828, described from Liberty County, Georgia) differs generally from *Microtus* in its greater specialisa-

tion for burrowing. The usually short fur is denser and finer, the ears and tail shorter, the eyes smaller, and there are usually only five plantar tubercles, and four mammæ confined to the inguinal region, the four pectoral mammæ of *Microtus* being absent. In the least modified species the skull differs little from that of many of the more primitive species of *Microtus;* the inter-orbital region is relatively broad, the temporal ridges little developed, the brain-case large, often depressed, and smooth. In the more specialised forms the fossorial characters of the skull (oblique truncation of occiput, straightening of the upper incisors, and the characters correlated with these two) are marked. The cheek-teeth grow persistently; m^1 and m^2 are normal, the latter sometimes with a vestigial third inner angle recalling the *agrestis* group; m^3 has three outer and three or four inner salient angles, and when most reduced its first outer triangle tends to atrophy, and is more or less confluent with the inner triangle. m_1 has three instead of five closed triangles, the pair behind the anterior loop being broadly (in European) or half (in some American species) confluent (Fig. 77); m_2 has only two closed triangles, the anterior pair being half-confluent; m_3 is normal. This description applies to all the known American and European species, but in Asia species occur which partially bridge the gap between *Pitymys* and *Microtus.* Thus Thomas has found six mammæ (including a pectoral pair) in his *P. majori* (described from Trebizond, Asia Minor, *Ann. and Mag. Nat. Hist.*, April 1906, 419), and eight (four pectoral) in his *P. carruthersi* (from the Hissar Mountains to the east of Samarkand, Turkestan (*Ann. and Mag. Nat. Hist.*, March 1909, 263); in both these forms also the tail and ears are rather long. Three species, ranged at present with *Microtus,* viz., *M. irene, millicens,* and *oniscus,* have been described by Thomas from eastern Asia; in these the dental characters of

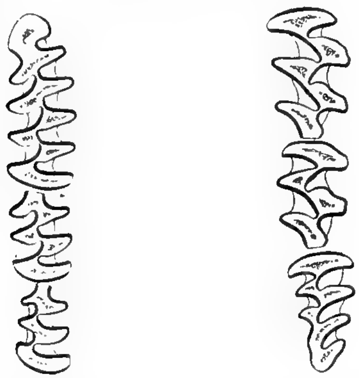


FIG. 77.—*Pitymys subterraneus.* RIGHT UPPER AND LEFT LOWER CHEEK-TEETH; crown view; 10 times life size. (Drawn by M. A. C. Hinton.)

Pitymys are combined with a peculiar skull (resembling, however, that of some species of *Microtus*, rather than any of *Pitymys*) and the essential external characters of *Microtus*.

Pitymys is of rather southern distribution, ranging in the Old World from Belgium, France, eastwards to Rumania, and south to the coast of the Mediterranean, including Greece, Sicily, and Trebizond, Asia Minor, while one species at least inhabits central Asia (Turkestan). In the New World it is found in the eastern and south-eastern United States, with Mexico.

It is numerous in species, no less than twenty-five distinct forms being recognised by Miller as European. Of these, *P. subterraneus*, De Selys, is present in Belgium and northern France, just across the English Channel. In Britain it makes its earliest known appearance, the remains of three or four species having been found in the Cromerian Upper Freshwater Bed, a late Pliocene deposit. It may then have died out, for, with the exception of a single m^2 doubtfully ascribed to it by Hinton from the early Pleistocene ("High Terrace") of the Thames Valley, no trace of the genus is known from the succeeding epochs.

Hinton regards the original home of *Pitymys* as in central or southern Asia, whence he believes that it spread westwards *via* Asia Minor to western Europe, and eastwards to North America by north-eastern Asia. The discovery of slightly more primitive species (*P. majori* and *P. carruthersi*) in Asia, and of the aberrant *M. irene* and its allies, lends support to this view.

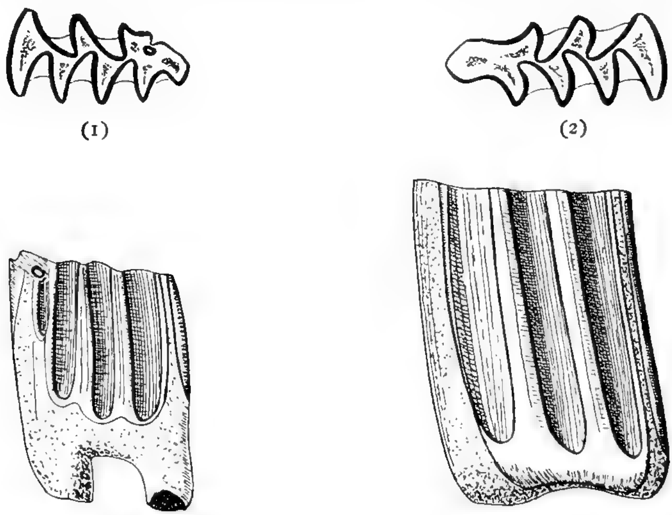
[Genus MIMOMYS.[1]

This genus was instituted by Forsyth Major (*Proc. Zool. Soc.*, London, 1902, i., 103-107) for his *M. pliocænicus* of the upper Pliocene of Italy, and the Norwich Crag of Britain; for his *M. newtoni* and for *Arvicola intermedius* of Newton (*Mem. Geol. Survey*, 1882, 83), both the last from the late

[1] Extinct. Wrongly assigned to *Phenacomys* by Nehring (*Naturw. Wochenschrift*, No. 231, 15th July 1894, 346), and subsequently included by him in his *Dolomys* (*Zool. Anzeiger*, 10th Jan. 1898, 15), from which latter it was distinguished by Forsyth Major (*supra*).

pliocene Forest Bed of Norfolk. Both *M. pliocænicus and intermedius* have since been recorded from the Pliocene of Tegelen-sur-Meuse, Belgium (Newton, *Bull. Soc. Belge Géol., Mém. Pal.*, 21, 592-6, 1908; 24, 231, 1910), and of Gorkum, Holland (Rütten, *Diluviale Säugethiere Niederlande*, 1909-10, 88); but Hinton believes that the specimens from Tegelen referred to *M. intermedius*, really belong to *M. newtoni*, or a near ally.

The genus is of peculiar interest, since it appears to represent the ancestral stock of modern *Arvicola*. Its members



(1) (2) (1*a*) (2*a*)

FIG. 78.—CHEEK-TEETH OF MIMOMYS: (1) left m_1 of *Mimomys pliocænicus* (crown view), from the pliocene Norwich Crag of England; (2) right m_1 of *M. intermedius* (crown view), from pliocene Upper Freshwater Bed of Cromer, Norfolk; (1*a* and 2*a*), external views of same; 2*a* is reversed to facilitate the comparison with 1*a*; 8 times life size. (Drawn by M. A. C. Hinton.)

are amongst the earliest microtines found in Britain, having been detected in the late pliocene Norwich Crag.

Judging from the jaws and teeth, some species (*M. newtoni*) agreed in size with medium-sized *Microtus*, others (*M. intermedius*) with lemmings. The general pattern of the cheek-teeth resembles that of *Arvicola*, but, instead of growing persistently as in the latter, they are provided with roots when adult. In *M. pliocænicus*, m_1 has in young stages of wear a third outer infold or valley formed in the way normal in cheek-

teeth of *Microtinæ;* in later stages (Fig. 78) this infold is reduced, its inner part being converted into an enamel islet which persists as a conspicuous feature of the grinding surface until a very advanced stage of wear has been reached. m^3 of this species has its second inner infold reduced by insulation of the internal part in a similar way. The roots of the cheek-teeth are developed early in the existence of the individual, and m^1 and m^2 have each three roots.

M. pliocænicus also occurs in the lower Forest Bed series at East Runton, and is there associated with more highly developed species, in which, however, the second inner infold of m^3 is not reduced. In two of these later species (*M. intermedius;* and *M. savini*, Hinton, *Proc. Geol. Assoc.*, 3rd June 1910, 491) the third outer infold of m_1 develops as in *M. pliocænicus*, but the process of reduction is accelerated; the enamel islet is found only in young stages of wear, and entirely vanishes before the roots begin to appear, which is at a later moment in the life of the individual than in *M. pliocænicus;* in addition, m^1 and m^2 have each only two roots. Hinton concludes that these later forms were not directly descended from *M. pliocænicus*, but from a similar, though slightly more primitive, animal. In the upper Freshwater part of the Forest Bed the more advanced species alone occur, *M. pliocænicus* having by that period become extinct.

Besides the above species, *M. newtoni* of the Norwich Crag and the lower part of the Forest Bed, is a small form with cheek-teeth of a less reduced type than those of *M. pliocænicus;* both in it and in *M. reidi* of Hinton, from the Weybourne Crag, the tooth-roots are formed early in life. The latter differs from *M. pliocænicus* in its small size, confluent dentinal spaces, and the much more transitory presence of the islet in m_1. In the upper Freshwater Bed of West Runton (top of the Forest Bed series), in addition to *intermedius* and *savini* noticed above, there occurs a third form, *M. majori* (Hinton, *op. cit.*); in this the third outer valley of m_1 is not reduced at all, but is normally developed. In the early pleistocene High Terrace Drift of the Thames Valley remains of another species have been detected, *M. cantianus* of Hinton (Hinton and White, *Proc. Geol. Assoc.*, June 1902, 414; Hinton, *op. cit.*, 491); the cheek-

teeth of this form resemble those of *M. intermedius* in pattern, but their roots are developed only in senile stages of growth. Remains of still other species of *Mimomys* are known from the late Pliocene deposits, but these have not yet been satisfactorily defined.]

GENUS ARVICOLA.

1799. ARVICOLA, Lacépède, *Tab. des Mammifères*, 10, based on *amphibius*; Lataste, *Le Naturaliste*, October 1883, 349 (sub-genus); Miller, *N. Amer. Fauna*, No. 12, 66, 23rd July 1896 (sub-genus); Miller, *Ann. and Mag. Nat. Hist.*, February 1908, 195 (genus).

1836. HEMIOTOMYS (sub-genus), E. de Sélys-Longchamps, *Essai Monographique sur les Campagnols des environs de Liége*, 7 (part), based on *Arvicola* (=*Microtus*) *fulvus* = *M. arvalis* and *A. terrestris* = *amphibius*.

1857. PALUDICOLA (sub-genus), J. H. Blasius, *Säugethiere Deutschlands*, i., 333 (part); based on *amphibius* = *scherman*, *nivalis*, and *ratticeps*; preoccupied by *Paludicola* of Wagler, 1830, a genus of amphibians.

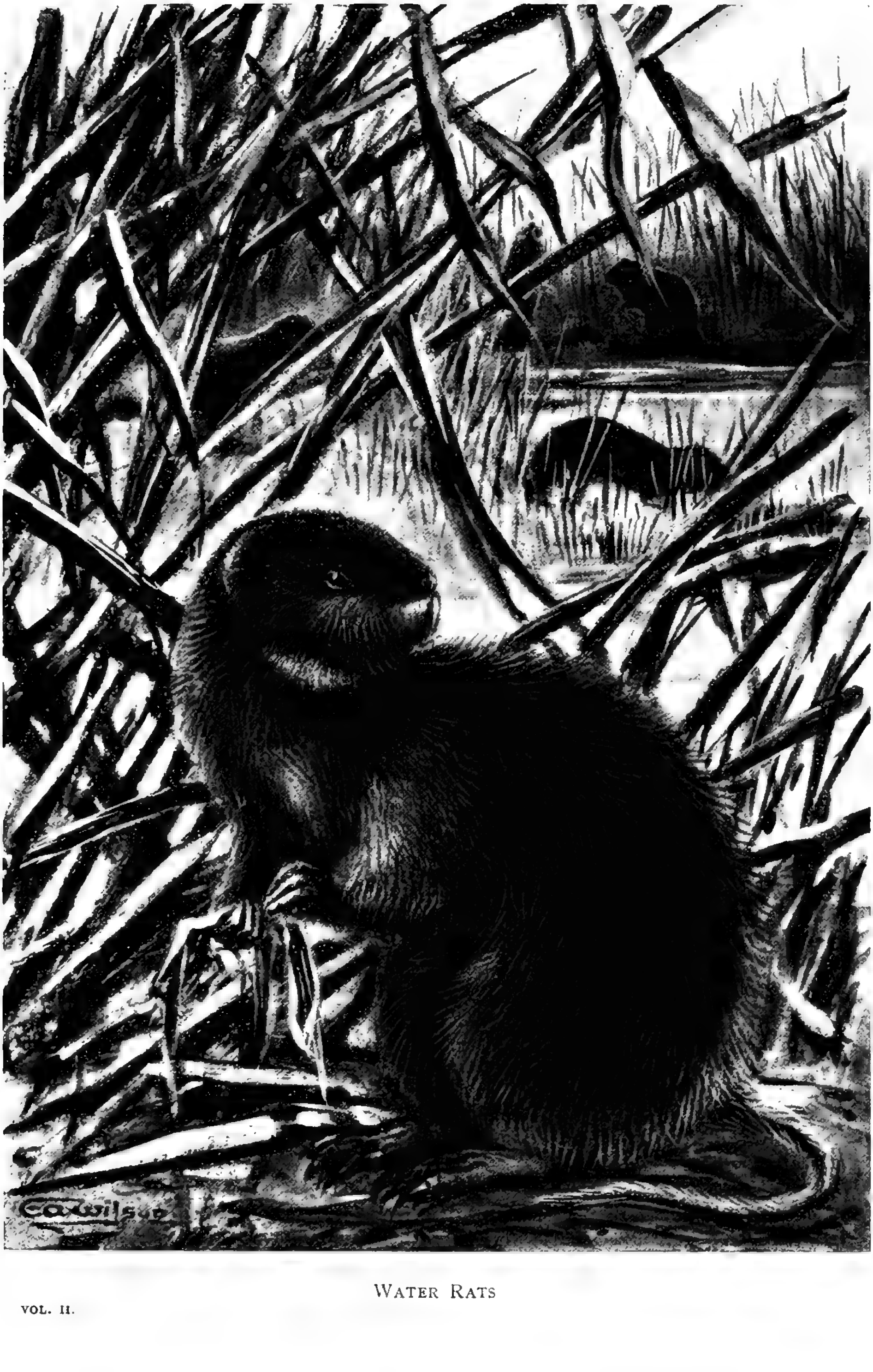
1867. OCHETOMYS, L. J. Fitzinger, *Sitzungsb. k. Akad. Wiss.* (Wien), lvi., June, 103; based on the Water Rats of Europe.

1867. PRATICOLA, Victor Fatio, *Les Campagnols du Bassin du Leman*, 36 (part); based on *amphibius* = *scherman*, *nivalis*, *arvalis*, *ratticeps*, and *campestris* (=*arvalis*); preoccupied by *Praticola* of Swainsson, 1837, a genus of birds.

Synonymy:—The full synonymy is given in Miller's *Catalogue*. The name *Arvicola* was for a time used to designate a large genus, including the bulk of the *Microti*. It is antedated in that sense by *Microtus*, but proves to be available for the Water Rats.

Although it is convenient to treat the Water Rats as a genus, they are not very sharply differentiated from the Grass Mice (*Microtus*), from which they differ mainly in their larger size; relatively longer tails; in possessing lateral musk-glands; normally five, instead of six, plantar pads; and m^3 with 3 + 3 salient angles and 2 + 2 infolds, as in *Chionomys*. Many of the species are aquatic; but others are more or less subterranean. The **fur** is long and suitable for commercial purposes, but, doubtless owing to the small size of the animals, is not widely used.

Distribution:—The Water Rats have a wide range in the Palæarctic Region, north of the Himalayas, from Norway (to the outermost Skerries) and Wales, at least to the river Amoor (Schrenck), and from the Norwegian shores of the Arctic Ocean with corresponding zones in Siberia to the Mediterranean coasts of Spain and France, Central Italy, Bosnia, Rumania,



Water Rats

Asia Minor to Northern Palestine (Tristram), west and north Persia, and the Altais. They ascend to about 4500 feet in the Alps and Jura (Fatio). The relationships of east Asiatic forms have not yet been worked out, and it is not known if they really belong to the genus *Arvicola*. *Microtus calamorum* of Thomas, described from reed-beds at Nanking, seems to be allied to the North American sub-genus *Aulacomys*, which in external form represents *Arvicola*, but has the enamel-pattern of *Microtus;* the single species inhabits boreal zones in mountains from Alberta south to Oregon.

Distribution in time:—Hinton finds small unidentified species of *Arvicola* in the middle Pleistocene of Grays Thurrock and Ilford, in which they appear to have represented *Mimomys* of previous horizons. The genus is not again encountered until the Ightham horizon, in which *A. abbotti* (Hinton, *Ann. and Mag. Nat. Hist.*, July 1910, 34) is numerous. This is undoubtedly a member of the *scherman* group, differing from existing species in its larger size and more extreme fossorial specialisation, as shown especially in the straightened incisors, sloping occiput, and greatly reduced inter-parietal. The genus may have owed its survival to the fact that, after the disappearance of *Mimomys*, it had no competitors, and had nothing to fear from subsequent immigrations, which seem to have caused the extermination of the older forms of *Evotomys* and of *Chionomys*.

Geographical variation:—Miller recognises seven European species, of which *A. amphibius*, the British Water Rat, is described below. *A. sapidus* of Miller, of the entire Iberian Peninsula and north through the Pyrenees at least to Garonne, France, is an aquatic form, most nearly allied to and resembling *A. amphibius*, but with broad nasals. *A. terrestris* (Linnæus) of Skandinavia, and eastwards at least into Russia, the Caucasus and Elburz Mountains, is smaller than *A. amphibius*, with yellower cheeks and skull slightly but evidently modified for a fossorial existence; the rostrum and occiput tend to be obliquely truncate, and the inter-parietal subquadrate in outline; the teeth are rather heavy, the upper incisors projecting, the roots of m_1 and m_2 not forming protuberances as in *A. amphibius*. *A. italicus* (Savi) of Italian Switzerland and Italy, at least to

Pisa, resembles *A. terrestris*, but has less heavy teeth, lighter colour, and cheeks not in contrast with the surrounding parts. *A. illyricus* (Barrett-Hamilton) of Bosnia differs from the last in having whitish under parts. *A. musignani* of de Sélys, at present known only from the west coast of central Italy (Rome), is a pallid edition of *italicus*. *A. scherman* (Shaw) is a fossorial and partially terrestrial form with three sub-species, inhabiting continental Europe from Belgium and the Baltic to the Pyrenees, Alps, and Tirol; it has both palmar and plantar pads reduced in size, the skull distinctly fossorial, the inter-parietal bone being narrow and ligulate, and the incisors projecting; one of its sub-species, *A. s. monticola* (de Sélys), of the Pyrenees is strictly terrestrial and mole-like, and is of special interest because of its relationship to *A. abbotti* of the late Pleistocene of Britain (see under *Distribution in time* on last page).

The **habits** resemble those of *Microtus*, except as modified by a special tendency to either an aquatic or a fossorial existence.

Origin:—*Arvicola* is evidently of Asiatic origin. The distribution of the North American *Aulacomys* suggests a real relationship, but the time has not yet come for a final decision.

THE BRITISH WATER RAT.

ARVICOLA AMPHIBIUS (Linnæus).

The British Water Rat occurs as two sub-specific forms described below. It is found all over England, Wales, and the mainland of Scotland, but is absent from Ireland and probably all other islands except Anglesey and Wight.

Terminology:—It is the "Water Vole" of text-books, a name which originated, as in the case of other British species, with Fleming. All previous authors wrote of the "Water Rat," apparently translating the "Rat d'eau" of French naturalists (*e.g.*, Buffon, *Hist. Nat.*, vii., 368, t., xliii.). Jenyns's "Water Campagnol" seems never to have become popular. The word "craber" from the French crabier, an abbreviation from *raton crabier* (*cf.* Walton, *Complete Angler*, ed. 2, 73, 1655, "the craber which some call the water-rat"), seems to have fallen into disuse.

Local names (non-Celtic):—*black*, or *water dog*, Aberdeenshire (Macgillivray); *earth-hound* (*cf.* Norwegian *Jordrotte* = "earth rat") heard once by Sim; *water mole* of Cambridge (Jenyns); *water ratten* of upper Nidderdale; *water rat*—universally.

(Celtic):—Scottish Gaelic—*radan-uisge* = "water rat" (C. H. Alston); *lamhalan*, perhaps from *famh-alan* = "water mole." Welsh—*llygoden y dwfr* = "water rat" (Forrest).

In general appearance and **characters** the British Water Rat is typical of the genus *Arvicola;* in size it is larger than other European species, excepting *A. sapidus.* The tail is somewhat more than half as long as the head and body. As compared with *Epimys norvegicus* it has the body heavier and more robust, the tail relatively shorter, and the head distinctly more rounded. Although the ears (Pl. XXVI., Fig. 1) are well developed, they are inconspicuous, barely show above the fur, and when laid forward hardly reach half-way to the eyes. They are on both surfaces thinly clothed with rather long hairs, subcircular in outline, and with well-developed, bluntly triangular, naked meatal valves. The small eyes lie about half-way between the ears and the muzzle. The nostril-pad is small and naked, its lower border continuous with the naked median groove of the upper lip. The upper incisors project slightly when the mouth is closed.

The **hands** are broad and robust, but not specialised in any particular direction; the rudimentary thumbs are smaller than the smallest palmar pads, but carry distinct nails covering their dorsal surfaces; digit three is longest, slightly exceeding four, as four does two, five reaching about to the base of four; all the digits are scaled on their under surfaces, and carry slender slightly curved claws, equal in length to about one-quarter of their digit.

The **feet** are large and slightly fringed, apparently for swimming; of the digits the first is smallest, reaching about half-way to the base of the second; the second, third, fourth, and fifth are much as in the hand, as are the scales and claws, the latter, however, stronger than in the hand; except for a slight sprinkling of hairs on the posterior third, the soles are naked. The pads are variable both in size, and, sometimes, in number, being evidently in course of reduction. As a rule they are comparatively small, and the small internal proximal one appears only as a smooth spot, so that the total is normally five, but occasionally six are present. In one specimen the feet showed a confused mass of tumid flesh without true differentiation into pads.

The **tail** tapers noticeably from a thick base; when laid forward it reaches about to the shoulders or slightly beyond; the annulations are irregular, but clearly visible and not concealed by the hairs—about 15 to the centimetre at the middle of the tail. The numerous hairs are 4 to 5 mm. long and form a slight terminal tuft.

The **mammæ** are as in *Microtus.*

There are on the flanks, about half-way between the root of the tail and the scapulæ, paired **vascular glands**, oval in structure (17 × 12 mm.

in size), and each with its long axis parallel to that of the body.[1] Their slightly raised surfaces are closely and irregularly wrinkled so as to present a honeycombed appearance, caused by a series of pits, from the cavities of which arise hairs resembling those of the ordinary pelage; these hairs become scarcer towards the centre of the glands, so that they may sometimes appear to be naked; in dried skins their positions are indicated by the grease-soaked fur. These glands recall those of the shrews.

The **fur** is close, dense, and long; the underfur thick and woolly.

The **colour** (when not melanic) is normally dark brown, varying from "broccoli-brown" to "mars-brown" or darker, deeper along the back, lighter but not decidedly yellowish on the face and sides; the cheeks not in contrast with the surrounding parts. The sides are usually somewhat "lined" with black. The chest and belly vary between ochraceous-buff and slate-grey, the latter derived from the basal portions of the hairs. The feet are some shade between "hair brown" and "ecru drab," sometimes blackish; the tail is blackish, the underside sprinkled with greyish hairs.

There are two irregular **moults**, the summer coat being shorter and often redder, owing to the absence of the long hairs with dark tips. The post-juvenal coat of the young resembles that of the adult in summer.

The **skull** is large, with prominent ridges when old, and, as compared with that of *Microtus*, the occiput and rostrum tend to be obliquely truncate instead of nearly vertical; the nasals at their widest region (in front) are conspicuously narrower than the rostrum; the incisive foramina are much shorter and narrower; the auditory bullæ are relatively small; and the basi-occipital wide.

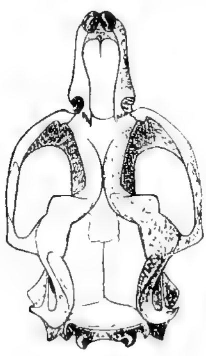


FIG. 79.—DORSAL VIEW OF ADULT SKULL OF *Arvicola amphibius*; natural size. (Drawn by M. A. C. Hinton.)

In the **teeth** the upper incisors, which are anteriorly deep yellow, are not conspicuously projecting; compared with those of *Microtus* they are somewhat straightened and protruding, but to a much less extent than in the *scherman* group. The cheek-teeth (Pl. XXVIII.) are large and heavily built, the enamel-pattern well defined and distinct, with sharp and definite angles; the base of m_1 forms evident protuberances on the lower surface of the mandible in old individuals. m^3 is simpler than in *Microtus*; the anterior loop is followed by a small outer and a larger inner closed triangle; the terminal loop is simple; a third closed external triangle is sometimes isolated; this tooth has on each side normally three salient

[1] Adams kindly examined a number of individuals for these glands; he finds that they occur in both sexes.

angles and two infolds, the posterior angles being sometimes poorly developed.

m_1 has the posterior loop preceded by three alternating closed triangles, two of which are internal; in front of these are an outer and an inner triangle, more or less confluent with each other, and opening into the short rounded anterior loop; the fourth (second outer) triangle is sometimes closed, and then the tooth has an appearance recalling m_1 of *M. ratticeps;* there are three outer and four inner infolds, and the same number of salient angles, with, in addition, a more or less prominent vestige of a fourth outer and a fifth inner angle anteriorly; the latter are clearly defined in very young teeth, but disappear rapidly with wear.

The remaining cheek-teeth are essentially as in normal *Microtus;* m^2 has three outer and two inner salient angles; in m_2 the anterior triangles are not completely cut off from each other by the antero-external fold; in m_3 the outer triangles are well developed, and the postero-external fold is usually deep enough to isolate the first outer from the first inner triangle.

Status, origin, and distribution in time:—*A. amphibius* is most nearly allied to *A. sapidus* of southern France and the Iberian Peninsula, and not to the Skandinavian *terrestris.* It probably owes its distinction from *sapidus* to isolation. It is not known as a fossil, the representative of the genus at Ightham being *A. abbotti*, a member of the older *scherman* group. It is evidently a recent member of the British Fauna, not old enough to have reached any of the islands except Anglesey and Wight.

The sub-species are as follows:—

THE SOUTH BRITISH WATER RAT.

ARVICOLA AMPHIBIUS AMPHIBIUS (Linnæus).

1758. MUS AMPHIBIUS (species), Carolus Linnæus, *Systema Naturæ*, x., 61, xii., 62, 1766; described from England and based on the *Mus major aquaticus* of Ray; Berkenhout; Turton; Walker; Bingley; Donovan.

1828. ARVICOLA AQUATICA, John Fleming, *History of British Animals*, 23; the specific name from Leach, *Syst. Catal. Spec. Indig. Mamm. and Birds, British Museum*, 1816, 7 (a *nomen nudum*); Gesner (1551); Merrett (1666); Charleton (1668); Sibbald (1684); and Ray (1693).

1835. ARVICOLA AMPHIBIA, Leonard Jenyns, *Manual of British Vertebrate Animals*, 33 (part); Bell, ed. 1 and 2; MacGillivray; Owen (part?).

1842. ARVICOLA AMERICANA, J. E. Gray, *Ann. and Mag. Nat. Hist.*, 226; described from half-grown specimens supposed to have been taken in South America, and of which co-types are in the British Museum.

1845. ARVICOLA AMPHIBIUS, sub-var. NIGRICANS, E. de Sélys-Longchamps, *Atti della Sesta Riunione degli Scienziati Italiani* (Milan), 1844, 322; without description, hence a *nomen nudum*.

1857. ARVICOLA AMPHIBIUS (a.) J. H. Blasius, *Saugethiere Deutschlands*, 344 (part).

1895. MICROTUS AMPHIBIUS, Richard Lydekker, *Hand-book to the British Mammalia*, 216; Aflalo; Johnston.

1905. ARVICOLA AMPHIBIUS, J. G. Millais, *Mammals of Great Britain and Ireland*, ii., 287; Pycraft, British Museum *Guide to the British Vertebrates*, 1910, 8 and 81.

1910. ARVICOLA AMPHIBIUS AMPHIBIUS, G. S. Miller, junr., *Proc. Biol. Soc. Wash.*, xxiii., 19, 23rd March, and *Cat. Mamm. Western Europe*, 1912, 730.

1910. ARVICOLA TERRESTRIS AMPHIBIUS (part), E. L. Trouessart, *Conspectus Mammalium Europæ*, 194.

The **synonymy** is that of the species and typical sub-species *amphibius*; that of the black sub-species *reta* is given in the article on that animal. The British Water Rat is undoubtedly the *Mus amphibius* of Linnæus, who adopted it from Ray's *Mus major aquaticus* of England. He states that it is a species not closely examined by himself, and perhaps not really distinct from his *Mus terrestris*, under which name he had just previously lumped all the other European water rats. Misled by Ray he described it as *plantis palmatis*, i.e., with the hind feet webbed, which led Gilbert White (letter x. to Pennant, 4th August 1767) to comment on the description, which he found, but for the webbed feet, applied exactly to a rat which he had himself discovered on the banks of "our little stream."

Distribution:—This is the Common Water Rat of England and southern Scotland, where it is numerous in suitable localities throughout the mainland, and occurs in the Isle of Wight and Anglesey. It ascends to 800 or 1000 feet in Wales (Forrest); and in Dumfriesshire, in May 1887, W. Evans saw a buzzard catch one on the hills above Loch Skene, at an elevation of about 2000 feet. Somewhere north of the watersheds of the Clyde and Tay (H. A. Macpherson and Aplin, *Zoologist*, 1892, 281-293), it gives way to the northern sub-species *reta*, but no exact details are available. There are black colonies in Norfolk and Cambridgeshire, the status of which is not known.

Description:—This is a large Water Rat, with hind foot reaching 32-35 mm., and condylo-basal length of skull 42 mm. or more in adults. The colour is moderately dark, black rarely replacing brown on the upper surface, and melanistic specimens are comparatively rare.

Exceptional variations are comparatively frequent, and there are a good many records of partial or complete albinos, as well as of pied (see Service, *Ann. Scott. Nat. Hist.*, 1896, 206), grey, and reddish sandy individuals. As is usual in such cases, the tendency to variation in a particular direction seems to be inherited, and more than one white or whitish individual may be observed in the same locality at or about the same time.

Melanism (considered apart from the regular sub-species, *A. a. reta*) is rather frequent, but local, being considered rare in the south of England and Wales. Millais gives a list of counties in which it has been observed, and remarks that the southern melanistic specimens are darker in summer than in winter, and are never so black as those from the north of Scotland, *i.e.*, as *M. a. reta.* White spots on breast, forehead, or tip of tail are frequent (see Service, *Ann. Scott. Nat. Hist.*, 1904, 66-67).

Skull (adults):—Condylo-basal length, 40 to 44·6; breadth: at zygomata, 23·6 to 26; at inter-orbital constriction, 4·2 to 5·4; at occiput, 17·8 to 20·6; median occipital depth, 10·4 to 11·6; length: of nasals, 10·2 to 12·2; of diastema, 13 to 15·6; of mandible, 24·8 to 29·8; of maxillary tooth-row, 9 to 11·4; of mandibular tooth-row, 9·4 to 11·4.

THE BLACK WATER RAT.

ARVICOLA AMPHIBIUS RETA, Miller.

1832. ARVICOLA ATER, William MacGillivray, *Mem. Wernerian Nat. Hist. Soc.*, vi., 429 (published January); described from Aberdeen, Scotland; preoccupied by *Hypudæus terrestris*, *β. ater* of Billberg, 1827 = *Arvicola terrestris.*

1835. ARVICOLA AMPHIBIA, var. *β.* A. ATER, Leonard Jenyns, *Manual of British Vertebrate Animals*, 33.

1910. ARVICOLA AMPHIBIUS RETA, G. S. Miller, junr., *Proc. Biol. Soc. Wash.*, xxiii., 19, 23rd March; a new name for the preoccupied *Arvicola ater* of MacGillivray; Trouessart; Miller (*Catalogue*).

History:—The Black Water Rat was described by MacGillivray in 1830, as distinct from "the brown kind," and confined to Scotland. He compared it only with brown individuals existing with it, with the result that he was unable to find satisfactory differences other than of size and colour, and consequently relinquished his species. In 1835 and 1841, Jenyns (*Ann. and Mag Nat. Hist.*, June 1841, 268-9), and 1846 (*Observations in Natural History*, 76), confirmed the differences in size, but noted a few exceptions, the largest he had ever examined having been black. He reported the occurrence of Black Water Rats sometimes known as "Water Moles," in the fens of Cambridgeshire. In Norfolk, Lubbock also noticed them, and drew attention to the "considerably" larger size of the brown forms, their different habits and custom of never mating with the black, thus suggesting their distinctness. In 1892, H. A. Macpherson and Aplin (*Zoologist*, 281-293), tracing the distribution of melanism in Water Rats, found that, although occurring sporadically in many widely separated districts of England, it is well established only in the fen country of Cambridgeshire and Norfolk. In Scotland it is very local south of the Trossachs in the west and the watershed of the Tay on the east coast; north of these districts black

individuals occur almost as generally as the brown. Macpherson and Aplin regarded these black animals as merely varieties. In 1910 Miller (*op. cit.*) confirmed MacGillivray's original opinion, but on different grounds. He showed that the black colour of Scottish individuals, being a geographically limited character accompanied by smaller size, is of sub-specific value. The sub-species undoubtedly needs further investigation, especially in regard to the black colony inhabiting the fen country, which may be composed only of melanistic examples of true *amphibius*.

Distribution:—North of the watersheds of the Clyde and Tay, the Black Water Rat is generally present and abounds in suitable streams and lochs, apparently to the exclusion of *A. a. amphibius*. There are no records as to how far it goes up the hills. Some writers (*e.g.* Lydekker) report it as absent from Argyll, but this is not the case. In the Forth district a colony has been known to exist near Colinsburgh, Fife, for many years (W. Evans). On the other hand, records of it from the Orkneys (Baikie and Heddle, *addendum*) are probably based on confusion with *Microtus orcadensis;* those from Islay, Mull (E. A. Alston), and Skye (Macpherson and Aplin, *op. cit.*), on *M. agrestis.* This sub-species must not be confounded with sporadic instances of melanism occurring in England. In Cambridgeshire and Norfolk, however, black individuals predominate so as almost to suggest that they represent an isolated colony of *M. a. reta.*

Description:—This Water Rat is on the average smaller than the typical sub-species. The hind foot usually reaches a length of not more than 30-32, and the condylo-basal length of the skull usually less than 42 mm. The colour is normally darker, and black often replaces brown on the upper surface; melanistic specimens are frequent.

Black and brown individuals may occur in the same litter (W. Evans, *Ann. Scott. Nat. Hist.*, 1910, 53).

Skull (Adult Male, British Museum, 5.5.12.1): — Condylo-basal length, 41·9; breadth: at zygomata, 24; at inter-orbital constriction, 4·2; at occiput, 18·5; median occipital depth, 11·3; length: of nasals, 12·2; of diastema, 13·5; of mandible, 27·9; maxillary tooth-row, 10·4; of mandibular tooth-row, 10·3.

Status:—Judging by its distribution and analogy with other mammals, the Black is an older form than the Common Water Rat, by which it has been driven out from the lower parts of the country, except perhaps Cambridge and Norfolk. But it cannot be a very old member of our fauna, since it is absent from all the Scottish islands. A statement of Boyd Watt—that the black form was first recognised in the Clyde area in August 1842 at Ballantrae, Ayrshire (whence John Thompson Sinclaire sent it to Thompson, see *Nat. Hist., Ireland*, iv., 1856, 13), but by John Colquhoun's time it had become

extinct, although previously common in the river Stinchar—at first sight supports the above supposition. Thompson, however, states that Sinclaire found "the ordinary animal much more common," so that we may be here only dealing with melanistic specimens of *A. amphibius* proper.

DIMENSIONS IN MILLIMETRES AND WEIGHT IN GRAMMES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
SEXUALLY IMMATURE MALES:—					
Arvicola amphibius amphibius—					
1. West Runton, Norfolk (A. Ruddle), 19th Sept. 1912	130	77	32	13	..
2. Six, Reigate, Surrey (L. E. Adams), Sept. and Oct. 1913	133	94	22	15	93
	165	111	33	14	165[1]
	172	117	34	16	170[2]
	175	105	35	15	170[3]
	175	112	35	18	180[4]
	185	115	35	17	218[5]
SEXUALLY IMMATURE FEMALES:—					
Arvicola amphibius amphibius—					
1. Three, West Runton, Norfolk (A. Ruddle), Sept. 1912	118	68	29	11	..
	129	83	32	14	..
	135	79	32	15	..
2. Seven, Reigate, Surrey (L. E. Adams)	155	115	33	15	164
	160	107	32	14	156
	165	103	32	15	163
	170	108	30	15	170[6]
	183	103	31	15	195
	185	112	30	15	175[6]
	185	125	35	15	185
SEXUALLY MATURE MALES:—					
Arvicola amphibius amphibius—					
1. Four, Reigate, Surrey (L. E. Adams), 1913	185	125	33	..	270
	190	110	34	..	241
	190	124	34	17	255
	195	140	35	18	284
2. Two, Earlsfield, Surrey (C. H. B. Grant), April 1899	185	110	31	17	..
	193	128	35	16	..
3. Thursley, Surrey (G. Dalgleish, *Zoologist*, 1908, p. 194)	192	129	36	17	..
4. Five, New Forest, Hants (G. S. Miller), 3rd July 1899	214	111	34	18	..
Do. do. 1st July 1899	214	127	38	16	..
Do. do. 5th July 1894	219	111	36	17·4	..
Do. do. 9th July 1894	219	132	36	17	..
Do. do. 1st Sept. 1894	219	136	39	18	..
5. Exeter, Devon (E. Hollis)	197	121	33	16	..
6. Two, Graftonbury, Hereford (De Winton), 22nd May 1894	205	130	81	..	..
Do. do. 21st June 1894	208	106	32	..	..
7. Diss, Norfolk	206	139	35	..	..
8. Two, Oundle, Northamptonshire (Cox), 12th June 1904	204	114	32	20	..
	208	125	29	18	..
9. Four, Read's Island, River Humber (Capt. D. E. Hume), 28th Feb. 1896	185	127	33	15	..
	190	123	32	14	..
	194	127	32	12	..
Do. do. 28th March 1896	207	140	37	15	..
10. Waith Beck (G. H. Caton Haigh), 15th May 1895	210	118	36	..	..
Averages	201·3	124	34	15·8	..

[1] Testis 4 mm. in diameter. [2] Testis 4 mm. in diameter. [3] Testis 5 mm. in diameter.
[4] Testis 9 mm. in diameter. [5] Testis 5 mm. in diameter.
All these specimens were born in the year of capture. (Adams.)

[6] With the exception of these two specimens all were imperforate; all were born in the year of capture; and none (including the perforate specimens) would breed before the following spring. (Adams.)

DIMENSIONS IN MILLIMETRES—*continued*:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
Sexually Mature Females:—					
Arvicola amphibius amphibius—					
1. Five, Reigate, Surrey (L. E. Adams), 1913	175	120	34	16	213
	175	120	34	16	225[1]
	181	120	33	17	226
	185	125	33·5	..	..
	205	144	35	16	255
2. Three, Shalford, Surrey (W. R. Ogilvie-Grant), Sept. 1906	183	112	31	17	..
	186	108	31	17	..
	201	117	33	17	..
3. Two, New Forest, Hants (G. S. Miller), 2nd July 1893	195	105	37	16	..
Do. do. 1st July 1894	204	125	36·4	16	..
4. Two, Exeter, Devon (E. Hollis)	178	110	32	16	..
	182	108	33	15	..
5. Cheadle, Staffordshire	185	118	33	..	..
6. Great Kimble, Bucks (E. Hollis)	185	119	33	18	..
7. Wendon Lofts, Essex (A. Wright), 13th Dec. 1894	170	92	30	..	..
8. Cambridge (Tom Orpen), 26th May 1894	189	118	30	..	241
9. Two, West Runton, Norfolk (A. Ruddle), Sept. 1912	174	104	34	18	..
	186	122	35	16	..
10. Two, Great Grimsby, Lincs (G. H. Caton Haigh), 15th Nov. 1895	174	114	28	..	..
Do. do. 24th July 1895	220	113	30	..	..
11. Two, Read's Island, River Humber (Captain Hume), 28th March 1896	190	123	32	14	..
Do. do. 29th March 1896	194	127	32	12	..
Average	187·1	116·5	32·7	16	..
Males:—					
Arvicola amphibius reta—					
1. Glenfesshie Forest, Inverness-shire (G. A. Cooper), 29th April 1905	190	125	32	16	..[2]
2. Lanbryde, Morayshire (W. Taylor), 30th Jan. 1911	163	102	32	16	..
3. Collieston, Ellon, Aberdeenshire (Hon. J. E. Edwardes), 28th Aug. 1912	172	88	33	15	..
4. Cortachy, Forfarshire (E. A. Wilson), 27th July 1908	163	96	32	17	..
5. Two, Windygates, Fife (N. B. Kinnear), 2nd July 1905	174	113	31	15	..[3]
	160	108	32	15·5	200[3]
6. Two, Blackwood, Kirkmuirhill, Lanarkshire (N. B. Kinnear), 25th March 1904	169	100·5	31	..	..[3]
Do. do. 22nd April 1904	183	107	31	..	..[3]
Females:—					
Arvicola amphibius reta—					
1. Cortachy, Forfarshire (E. A. Wilson), 27th July 1908	162	97	32	17	..
2. Windygates, Fife (N. B. Kinnear), 2nd July 1905	194·5	109	30·5	14·5	148
Do. do. 8th August 1904	182	114	31	18	..[3]
Do. do. 26th Oct. 1906	160	102	30	14	..[3]
Do. do. 26th Oct. 1906	157	95	29	14	..[3]
Do. do. 24th Oct. 1906	155	95	28	15	..[3]
3. Kirkmuirhill, Lanarkshire (N. B. Kinnear), 5th Oct. 1904	163	..	33	14	156[3]
Do. do. 9th Oct. 1904	152	96	31	13	142[3]
Do. do. 9th Oct. 1904	142	92	32	13	128[3]
Do. do. 10th Oct. 1904	154	91	31	14	142[3]

[1] With 5 large embryos.
[2] The skull shows that this specimen is an aged individual; the condylo-basal length is 41·9 mm., the ridges are strongly developed and fused in the inter-orbital region.
[3] All these specimens are probably immature, and some of them are brown in colour.

Water Rats may be regarded as large Grass Mice which have adapted themselves to a predominantly aquatic life, but without specialising so far as to lose the power of resuming a terrestrial existence. Their love of water is shown in their comparatively long tail, used no doubt for steering purposes; thicker, more beaver-like coat; well developed aural valves; reduction in size and number of foot-pads; and slightly fringed feet. In other respects they have not been specially modified in any really important detail for amphibian existence; but their life by ponds and watercourses has led them to construct a somewhat peculiar type of burrow, and they show a preference for certain water-loving herbs, which are not usually in the path of the ordinary Grass Mice.

Our own Water Rat, although a comparatively large animal and hunted by many predatory creatures, to which it is extremely palatable, manages to exist in numbers in a region wherein all other members of its sub-family, except the smallest, have been exterminated. Several large voles allied to or identical with the Skomer Bank Mouse, the Northern and Orkney Grass Mice and the Snow Mice,[1] flourished in south Britain in the late Pleistocene period, but now exist only in the sanctuaries afforded by islands or mountainous regions. The Water Rat alone remains, partly no doubt because it has no direct competitors amongst the members of its own sub-family and partly because it has adopted the happy expedient of relying on water for a retreat from its enemies. By doing so it incurs the risk of being snapped up by herons,[2] pikes, large eels,[3] and trout, and it is a staple food of owls, stoats, polecats and, perhaps, foxes; but it avoids many of the other enemies of its tribe. Like all water dwellers in cold or temperate countries it suffers from inundations which drive it from its burrows; from frost, a combination of these two being most inconvenient; or droughts; but on such occasions it is always at least as much at home on dry land as would be a Grass Mouse

[1] *Chionomys*, see p. 470.

[2] J. G. Millais has seen a heron kill a small one, and T. A. Coward and Charles Oldham find the pellets thrown up by herons (*Cheshire*, 55) consisting almost entirely of the fur of Water Rats.

[3] *Nat. Hist. Trans. Northumberland and Durham*, v., 1877, 341; for an eel seizing a Water Rat's tail, see J. D. Patchett, *Field*, 12th September 1891, 431.

of similar size, and, not being by any means lacking in climbing powers, it regularly takes refuge in the stumps of old willow trees.[1] During protracted floods large numbers are sometimes destroyed, but the altered conditions seem never to last long enough to effect the animal's extinction, and its numbers recover in the security of the ponds and ditches and sluggish rivers, which, rather than swift, gravelly streams, are its favourite summer haunts. But it is not tied to these, and when abundant may be found almost anywhere within a reasonable distance of water—in gardens, corn-fields, coastal marshes, hill-streams, or even sand-hills by the sea-shore.[2] In the north-western Highlands it frequents the limestone burns, where it takes shelter in holes in the limestone.[3]

It is at all times an expert swimmer and diver, vastly more so, as Mr A. H. Cocks has observed, than the scarcely less aquatic Brown Rat,[4] but, although it progresses rapidly under the surface, its methods are those of ordinary terrestrial mammals, since it uses all four limbs for purposes of propulsion, and on the surface swims with its head and upper part of its back above the surface. Mr Aubyn Trevor-Battye[5] has, however, observed that, when it is not in a hurry, its fore legs may rest at its sides, the hind legs doing all the work.[6] There is no evidence to show how long it is capable of remaining below the surface. If frightened, it usually contrives to emerge under some cover.[7]

Although the young are for some time comparatively helpless, they can swim at an early date, even before their eyes open.[8] Monsieur Fernand Lataste has described the first attempts in this direction of a young male of the allied continental Water Rat.[9] This was taken from its nest before its

[1] E. Hollis (*MS.*) took one from a hole in an oak, 12 feet above the ground. The tree not being hollow, the rat must have climbed up by the outside.

[2] H. A. Macpherson ; W. Evans.

[3] J. A. Harvie-Brown and Macpherson, *North-west Highlands*, 1904, 42.

[4] Millais (ii., 292) strangely puts the facts in exactly the opposite way.

[5] *Pictures in Prose*, 1894, 215.

[6] Beavers swim with the fore paws motionless under the chin (L. E. Adams).

[7] According to Mr Douglas English, *Some Smaller British Mammals* (undated), if cover is absent, it will bring up a leaf or other material in its mouth from the bottom.

[8] H. G. M. Williams, *Zoologist*, 1857, 5788.

[9] *A. sapidus.*

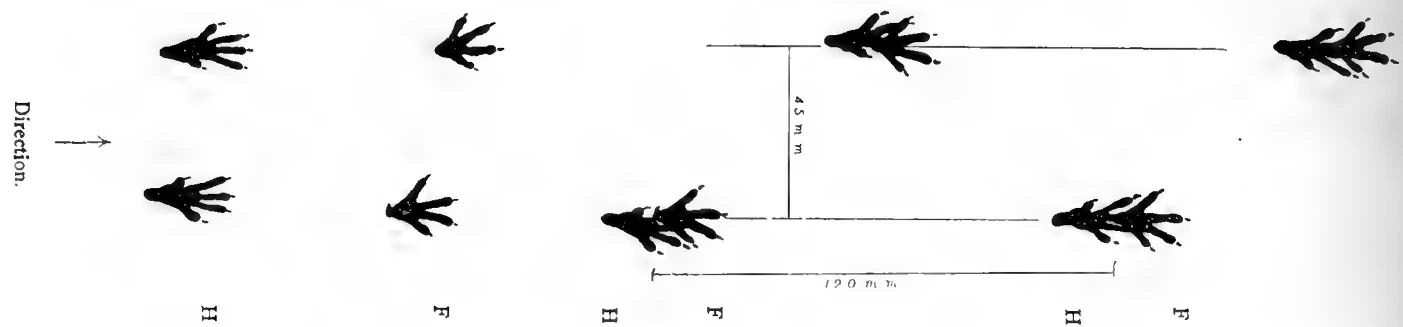


FIG. 80.—SPOOR OF WATER RAT IN SNOW.

(From a Sketch by L. E. Adams.)

H = Marks of hind feet; **F** = Marks of the fore feet.

Each hind foot strikes the ground a little behind the point vacated by the corresponding fore foot; in this track the left imprints are well in advance of the right ones.

[*To face p.* 488.

eyes had opened and soon began to show discontentment by its cries and restlessness. The moment it was given access to water it became happy, but on the first day restricted its natatory excursions to traversing the vessel in a straight line, keeping its head always dry. The next day it crossed, still in a straight line, but below the surface. The third day it dived again, circling many times before emerging, and from that time it continued to perfect its aquatic education.

The Water Rat has a second quite distinct tendency not usually recognised by those who regard it as an almost entirely aquatic animal, namely, a mole-like power of digging. It may thus be caught in regular mole-runs,[1] or may even excavate its own tunnels, throwing up "hills" at intervals in their construction. This is a procedure which it sometimes adopts when raiding gardens or grass-plots,[2] to reach which it sometimes travels long distances from water, one having been taken, for instance, in the stables of Hopton Rectory, at a distance of about a mile from the Little Ouse,[3] and another in a kitchen garden in a small town.[4] One identified by J. H. Gurney[5] was killed on the lighthouse-cliffs of dry sand at Cromer, Norfolk, some miles from any running stream.

Like the Water Shrew amongst British insectivores, the picturesque surroundings of its most favoured haunts, its diurnal habits and non-sensitiveness to observation, perhaps owing to its poor sight, have combined to render it an attractive animal to lovers of nature; its size renders it easy to observe, so that its method of eating, swimming, and transportation of its young have often been described[6]; all are, however, quite

[1] William Thompson, E. W. H. Blagg, *Zoologist*, 1894, 223; *Field*, 27th February 1909, 377; H. Laver, *Journ. cit.*, 6th March 1909, 419. This propensity appears at its height in the continental *A. scherman*, some races of which are entirely terrestrial and mole-like in their habits (D. Pierrat, *Feuille des Jeunes Nat.*, 1st March 1882, 62).

[2] J. Duns, *Proc. R. Phys. Soc.* (Edinburgh), session cix., 1879-80, 352-55, 1880; and session 1886-87, 325, 1887; Fleming (clover). H. Daniells, *Zoologist*, 1847, 1768 (grass); S. Gurney, *Journ. cit.*, 1851, 3265; Adams, *MS.*; Charles Stewart, *Hist. Berwick Nat. Club.*, xiv., 171; Millais.

[3] J. G. Tuck, *Zoologist*, 1898, 122. [4] E. B. Durham, *Field*, 27th June 1891, 980.

[5] *Field*, 21st April 1894, 550.

[6] One can "enjoy his society with greater intimacy than any other British mammal"—Millais, ii., 291; note also Calverley's poem on *The Water Rat*. It is often true that small mammals are more easily observed than large ones. W. P.

normal, except that, perhaps owing to danger from floods, it may carry its young about more than other animals, having been frequently noticed to transport the whole of its family in turn. The parent dives or swims with a young one in its mouth, holding it, according to Mr C. E. Pain,[1] who saw the removal of five half-grown youngsters, under the throat near the fore legs. The leaf of a water-lily often forms a temporary receptacle.

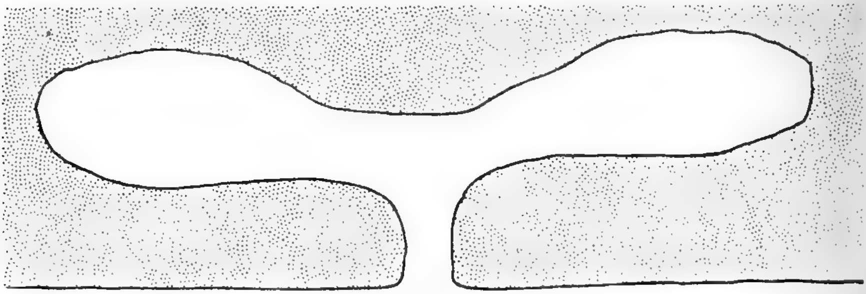


FIG. 81.—HORIZONTAL SECTION OF REFUGE OF WATER RAT, with two chambers, each large enough to hold one individual. (Diagrammatic, from a sketch by L. E. Adams.)

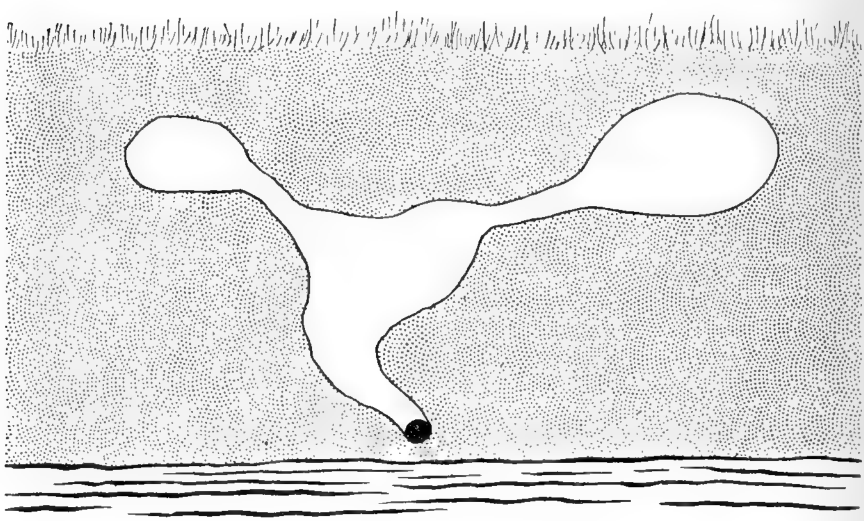


FIG. 82.—REFUGE OF WATER RAT IN A STEEP BANK (width of refuge, 7 feet), the entrance just above normal water-level; more complicated than in Fig. 81. (Diagrammatic, from a sketch by L. E. Adams.)

Taylor (*Mammals of the* 1909 *Nevada Expedition*, *Univ. California Pub. in Zool.*, 24th June 1911, 221) finds difficulty of approach bearing a direct ratio to the size of the species to be observed, and Elliott Coues had already come to the same conclusion (*Key to N. Amer. Birds*, ed. v., 15, 1903).

[1] *Field*, 6th June 1903, 950.

The burrows of the Water Rat have been specially studied by Mr L. E. Adams.[1] They are sometimes so numerous as to cause serious damage to embankments or masonry.[2] Although the entrances are frequently under water, that position is probably accidental, it being difficult to construct one below waterline. The funnels usually run straight for a distance of about a foot, after which they turn abruptly to right or left and end in an

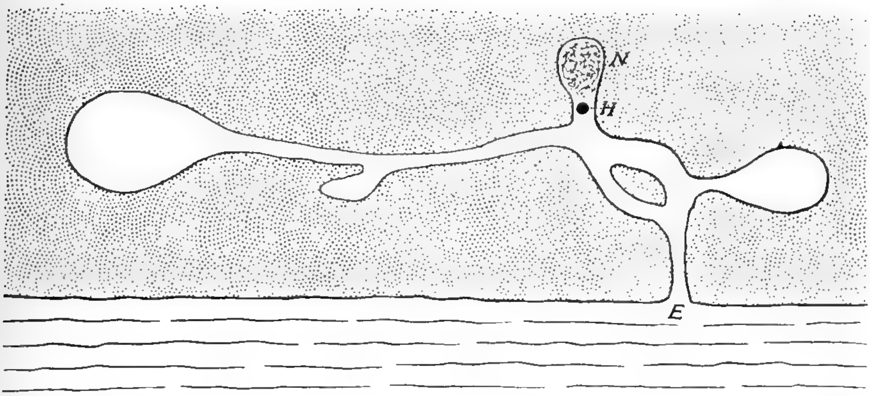


FIG. 83.—COMPLICATED BURROW OF WATER RAT (length, 6 feet), with Nursery (N), and Ventilation Hole (H), viewed from above. (Diagrammatic, from a sketch by L. E. Adams.)

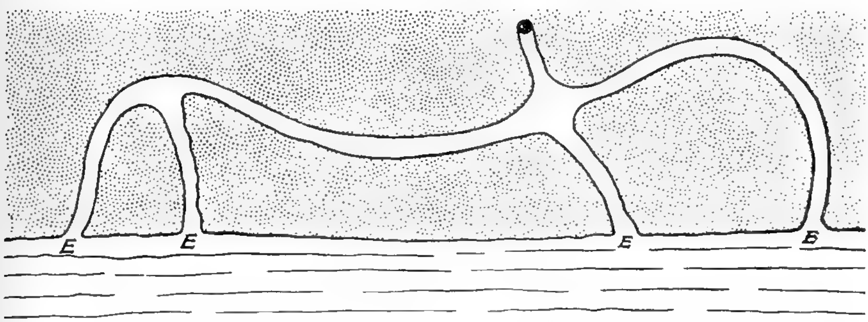


FIG. 84.—COMPLICATED BURROW OF WATER RAT (length, 10 feet); E, E, E, E, entrances at water front; entrance on land side blackened. (Diagrammatic, from a sketch by L. E. Adams.)

enlarged chamber. They are in such cases mere refuges into which the rats may retire for a short time when frightened. Sometimes they are Y-shaped with two terminal chambers,

[1] They were also described, although not altogether accurately, by P. H. Emerson, (*Norfolk*, 332).

[2] See, for instance, *Zoologist*, 1845, 858 (Anon.); S. Gurney, junr., *Journ. cit.*, 1851, 3265.

which may be at varying distances from the entrance, and at no time do the passages lead much below the surface of the ground, the type of excavation thus somewhat resembling that of Bank Mice.

The burrows rarely show any traces of occupation such as food, droppings (which are usually deposited by the water), nests, or nurseries. When the latter are present a ventilation hole may be provided, but where there are reed-beds or other herbage, they are quite frequently placed on the ground exactly like those of Grass Mice, and occasionally in hollow willow trees. In size and composition they resemble those of waterhens, the material used—reeds and grass—not being invariably shredded,[1] as is always the case with Grass Mice.

For breeding purposes the Water Rat prefers tributary streams and backwaters to main rivers. To these it retires in pairs early in spring, and the young, which sometimes number as many as eight,[2] may be seen on the banks throughout the summer, occasionally in April,[3] but more usually from May until autumn, so that several litters are probably reared by each couple. The male probably remains with his mate throughout the sexual season and does not harm his young; they probably grow at about the same rate as Grass Mice.[4]

The Water Rat, although without doubt predominantly a vegetable feeder, has, like others of its family, no objection to an omnivorous diet. The extent to which such wider tastes are indulged is, as in other similar cases,[5] very variable, depending probably on a number of predisposing factors. In eating, it usually sits up like a squirrel, holding the food in its hands, and where the favoured diet consists of roots or

[1] Adams, *MS.;* for a figure of a surface nest see M. S. H. Smith, *Naturalist*, 1912, 7; the surface nests were also described by Oldham, *Naturalist*, 1892, 4. Collett writes that the nests of the Norwegian *A. terrestris* have two entrances.

[2] Number of young:—Adams has found five (6th May), five, three, and two; Pennant, six fœtuses; Aflalo, seven; W. Evans (*MS.*), seven, still blind, in nest, 14th May 1898; Jenyns, eight fœtuses in a black female, 15th June 1830 (*Observations in Nat. Hist.*, 1846, 76); Collett reports ten in an *A. terrestris* in a special "vole" year.

[3] E. R. Alston.

[4] One still blind but able to swim, taken 16th June, opened its eyes on 23rd June—H. G. M. Williams, *op. cit.*

[5] Compare the Hedgehog, a primarily insectivorous, but frequently carnivorous mammal.

stalks they are often severed beneath the surface, brought up or allowed to float, and then recovered. Water Rats have been observed to eat, amongst other things, grass, clover, portions of sword-flags, purple loosestrife, winter cress, creeping ranunculus, marsh marigold, pondweed, leaves of duckweed, stems of the white water-lily, horse-tails, fallen leaves of willow, ivy and black poplar, acorns, and more rarely beet, mangels, swedes, and potatoes.[1] In winter it may attack the roots and bark of young trees and shrubs in orchards[2] or plantations,[3] and has long been known to be occasionally destructive to osiers and bullrushes. Messrs H. J. Charbonnier and C. Lloyd Morgan accuse it of climbing nut-bushes to carry off the nuts, and Mr C. E. Wright has seen one sitting on a bird's nest eating haws like a Bank Mouse. It has been convicted of devouring small fish, earthworms,[4] insects,[5] and even young ducks. The latter must be regarded as quite exceptional provender,[6] unless already dead,[7] the fish quite occasional, but the invertebrates more frequent. Mr F. J. Aflalo has seen it fishing up larvæ from the bed of the Hampshire Stour, Mr Gordon Dalgliesh[8] has taken it in traps baited with meat, Mr Forrest gives an instance of its eating a dead trout lying on the bank of a stream, and Mr A. Patterson[9]

[1] Five black Water Rats were found in a potato pit at Airds, Newabbey; R. Service, *Ann. Scott. Nat. Hist.*, 1904, 67.

[2] Duns, *op. cit.;* T. B., *Field*, 412 (piece of barked apple tree sent to editor).

[3] J. Hardy, on the authority of correspondents, stated (*Proc. Berw. Nat. Club*, viii., 189, 1877) that the roots of young sycamores, willows, and oaks planted near water frequented by Water Rats had been gnawed across, and the Water Rats were thought to have done the damage; but it does not appear that specimens were actually caught in the act. At Cocks's former home at Great Marlow, two or three magnolias of fairly large growth were killed at different times, by the bark being gnawed away just above the ground by Water Rats.

[4] It is sometimes recorded to have been taken with fishing flies, perhaps by an accidentally wide cast.

[5] E. R. Alston (in Bell); C. M. Butlin, *Field*, 15th October 1910, 758.

[6] Collett gives an instance of a Norwegian Water Rat emptying the nest of a wheatear.

[7] W. Evans saw a half-eaten young redshank lying at the entrance of a burrow; probably the bird was not killed by the Water Rats.

[8] *Zoologist*, 1902, 66; for a similar instance in the case of a roach, see P. M. Watkins, *Field*, 8th December 1907, 1024.

[9] *Trans. Norf. and Norw. Nat. Soc.*, vi., 293, 6th April 1897, 1899; *Zoologist*, 1898, 306 ("Mammalia of Great Yarmouth"); *Journ. cit.*, 1902, 111; *Eastern Norfolk*, 1905, 317; *Norfolk Estuary*, 1907, 335.

does not scruple to call it an omnivorous consumer of frogs, toads, crayfish, dead fish, and swan mussels.

The dead fish question he proved by observation and by pegging down a roach with the special object of catching the criminal. As to the deliberate catching of live fish, the Rev. F. R. Jourdain[1] has seen one eat a small trout, Mr W. P. Birch[2] reports an instance of a live minnow being taken when used as bait, and Mr H. H. Gray[3] believes that trout are taken up to 10 inches in length. Altogether there can be no doubt that the Water Rat will eat dead fish, but the evidence for its active piscivorous propensities in other directions, although supported by Charles St John, is meagre, and it certainly has not the Otter's ability to capture fish in fair pursuit.

The fact that Water Rats may eat fresh-water mussels was long ago suspected by J. H. Gurney,[4] R. F. Tomes,[5] and Sir Edward Newton, the latter of whom made the suggestion to Mr A. Patterson.[6] All three found very suspicious heaps of dead shells always perforated either nearly opposite, or else at the hinge. Mr Patterson has since seen one carrying a mussel, and the "signs" of the animals all around the heaps of broken shells—in this case always perforated on one particular side. Mr C. E. Wright[7] has also sent me an account of one eating a dead mussel which he observed himself, and he has also watched another fishing for water snails (*Limnæa stagnalis*), one of which was devoured in his presence.

A quite exceptional observation is that of Mr Charbonnier, who saw a Water Rat trying to drag into the river Trym a young rabbit larger than itself. Mr Charbonnier does not, however, think that the Water Rat had any intention of eating the rabbit, which screamed and escaped.

Water Rats are exclusive animals. A Brown Rat, if captured alive and caged with others of its species, usually—

[1] In Millais, ii., 295.
[2] *Field*, 16th July 1887.
[3] *Field*, 17th January 1903, 110.
[4] *Zoologist*, 1849, 2887.
[5] *Journ. cit.*, 1850, 2638.
[6] *Op. cit.*

[7] Wright observed a fight between a Brown Rat and a large crayfish, in which the latter by getting its pincers around the mammal's throat became the victor; and Adams has known Brown Rats to eat crayfish frequently. It is not always possible to distinguish the work of these two rodents, but undoubtedly the cap sometimes fits the Water Rat.

unless enraged by being hurt—makes its entry quite peaceably, and receives all further captives in a tolerant spirit; but a freshly caged Water Rat, like a Lemming, expects to be attacked, and generally has a short bout with all its fellow-captives in turn,[1] thus indicating that it lives in colonies or pairs each in its own territory apart from its neighbours. Of course when the colonies become crowded the sense of "property" indicated above cannot be so readily satisfied, but where the animals are not common, and during the breeding season, they have distinct "beats," as observed on the river Mole, near Reigate, by Mr Adams. These beats extend for about 20 yards along both banks, and the entrance of a stranger is always vigorously resisted, even by immature individuals whose riparian property is invaded. This sense of property rather interferes with the animal's character in captivity, since although naturally gentle and unaggressive, it bites furiously if its nest or its person are interfered with, and cannot be handled unless thoroughly familiar with its owner.

Although "plagues" of Water Rats are not frequently reported, there is evidence that the numbers of these animals are subject to the same extraordinary fluctuations as those of Grass Mice.[2] J. L. Knapp relates[3] that a large stagnant piece of water was thus suddenly infested one summer with an astonishing number, where none had previously been known; they disappeared in the following winter. Mr O. V. Aplin commenting[4] on their varying numbers in Oxfordshire, suggests that many perish during hard winters. Early in 1896[5] a serious "plague" was reported from Read's Island, consisting of some 600 acres of reclaimed pasture in the Upper Humber adjoining South Ferriby, Lincolnshire. This is said to have been reduced to the conditions of a rabbit warren by the burrowing propensities of the animals, which were described as "quite

[1] Cocks, *MS.*

[2] As also in Norway, where, however, Collett reports that the increase is chiefly local, and is coincident with that of *Microtus* and *Lemmus*. In Scotland, also, Service (*Annals Scott. Nat. Hist.*, 1896, 206) noted a marked increase during the "vole plague" of 1891-3.

[3] *Journal of a Naturalist*, 1829, 142.

[4] *Zoologist*, 1891, 304.

[5] See R. Payne-Gallwey, *Field*, 22nd February 1896, 294; F. Boyes, *Journ. cit.*, 29th February 1896, 336; also, *Eastern Morning News* of same date.

equal to that of the mole." Their food is stated to have been chiefly the roots of grass and thistles, quantities of which were found as if stored in the runs. Eventually the island was flooded by order of the owners, the Humber conservators, but probably the "plague" would have disappeared in the usual way. Judging from contemporary accounts it was three or four years coming on.

There is some disagreement as to whether the Water Rat accumulates winter stores of provisions, this habit not having been recently reported. The only positive evidence consists of the statement[1] by Gilbert White that a neighbour when ploughing a dry chalky field, removed from any water, "turned out a Water-rat, that was curiously laid up in an hybernaculum, artificially formed of grass and leaves. At one end of the burrow lay about a gallon of potatoes, regularly stowed, on which it was to have supported itself for the winter." The occurrence puzzled White, and since there is no evidence that he ever examined the rat himself, one is tempted to identify the store with that of a Brown Rat and to mark the identification as a mistake. Fleming, commenting on the above anecdote, remarked that he had twice witnessed the same thing, but since he seems to have believed that Water Rats hibernate in winter, the addition of a store is easily imaginable. On the other hand, since Collett states that such stores of potatoes and other food are usual in the Norwegian *A. terrestris*, it is probably right to regard the observations as correct descriptions of a habit rarely developed in mild climates.

The voice of the British Water Rat has not been described, but M. Lataste mentions that his continental captives emitted a small sharp cry and hissed. Adams caught one alive which emitted "low whistling squeaks" while struggling to escape; these sounds would have been inaudible at a distance of two or three yards.

The eyesight is probably poor, and M. Lataste suggests that all "voles" suffer from myopia. He thus accounts for the fact that a captive, finding itself accidentally on the balcony of a room high above a street, deliberately precipitated itself into space. M. Lataste suggests that it is a like bad eyesight that

[1] Letter xxvi. to Thomas Pennant, 8th December 1769.

renders the microtines generally such easy victims of pit-traps.

The British Water Rat has not been frequently tamed, but M. Lataste kept specimens of two continental forms,[1] some of the peculiarities of which have been mentioned above. Mr English[2] has also caged them; though thriving well in captivity, they are rather troublesome, requiring a large tank of water,[3] which they immediately soil with their droppings and making their cage and nest constantly wet after their aquatic excursions. Cocks has also frequently caged numbers of them, but for the above reason he has never kept them systematically, but has always used them as required, as very suitable food for Wild Cats. Some of M. Lataste's captives showed a tendency to arrange their bed near the water in such a position that they could drop into that element unseen if disturbed; although very assiduous in working at their nest they evidently felt most secure in the water.

The intelligence of the Water Rat is considerable, and it is capable of recognising particular persons; but in the opinion of M. Lataste it is in this respect inferior to the Brown Rat.

The maximum age attained in the London Zoological Gardens is 16 months,[4] but the natural life of the animal is probably much longer.

Sub-family *Murinæ*.

Characters:—The members of this sub-family, the typical mice and rats, are of varied external appearance and habits. They differ from the *Microtinæ* chiefly in being more perfectly adapted for gnawing; in retaining a preference for, and consequently a dentition suitable to the treatment of, a soft and succulent diet; and in leading more active and less earthbound lives. Their eyes and external ears are always well developed.

[1] *A. sapidus* and *A. scherman*.

[2] In Millais, ii., 293, etc.

[3] If not allowed to swim their eyes become closed by secretion of an oily matter drying like white wax (English).

[4] P. Chalmers Mitchell.

The principal muscles of mastication are the deep portions of the *masseteres laterales;* the temporal muscles are small, and their anterior portions show no tendency to increase in size and strength as in *Microtinæ.* In the **skull**, therefore, the lower maxillary roots of the zygomata, in order to accommodate the enlarged *masseteres laterales* muscles which rise from their outer surfaces, have grown into deep vertical plates of bone which project more or less considerably in advance of the slender upper roots of the zygomata which bridge the infra-orbital canals; the numerous specialisations, which in the skulls of *Microtinæ* are the outcome of hypsodont cheek-teeth and exceptionally developed temporal and pterygoid muscles, are wholly lacking; the tympanic bullæ are usually small relatively, and of simple structure, being without internal spongy tissue. The slender **mandible** has usually well-developed coronoid and angular processes.

The **incisor teeth** are, in transverse section, deeper than broad, instead of broader than deep as in *Microtinæ:* this difference of shape is an expression of the greater powers of gnawing possessed by *Murinæ,* in which these teeth are used as gouges, as compared with *Microtinæ,* in which the incisors have the function of cutting or shearing instruments (*cf.* Ryder, *Proc. Acad. Nat. Sci. Philadelphia,* 1877, 314).

The **cheek-teeth** are brachyodont and rooted; their crowns are composed in the most primitive forms of three longitudinal rows of tubercles, each row consisting primitively of at least three tubercles. The axis of each tubercle is more or less oblique to the base of the tooth; in upper molars the tubercles and their grinding surfaces have a general backward inclination, while those of lower molars are inclined forwards. In mastication there is thus little if any longitudinal motion between the upper and lower tooth-rows. The enamel thins out towards the summit of each tubercle and, even in unworn germs, does not cover the dentine at the apex (Hensel, *Zeitschr. deutsch. geol. Gesellsch.,* 1856, 283).

In order to give a clear view of the meaning of the variations in the structure of the cheek-teeth of the *Murinæ* and to facilitate their description, the cusps are numbered or lettered in accordance with the system of notation employed by Hinton.

This system is based upon the work of Winge, Fleischmann, Osborn, Forsyth Major, and Hinton[1]; it is illustrated in Plate XXVIII., in which cheek-teeth of *Cricetinæ*, *Microtinæ*, and *Murinæ* are comparatively represented.

In upper cheek-teeth the tubercles of the median row (x, y, z) are usually conspicuously larger than those of the outer or inner rows; those of the inner row have their axes more nearly vertical than have those of the outer and median rows, and in the various sub-families and individual genera of *Muridæ* this row of tubercles has suffered numerical reduction to a more marked extent than have the others. In *Apodemus*, for example, m^1 has three inner tubercles (Pl. XXVIII., Fig. 4, x', 6, 7); in *Epimys* this tooth has two, cusp 7 being lost; and in *Dendromyinæ*—an African group—only cusp 6 remains. The

[1] Winge (*Vid. Med. Nat. For. Kjöb.*, 1882, 15) came to the conclusion that three cusps, numbered by him from before backwards, 1, 2, and 3, which are prominently developed upon the outer sides of upper and the inner sides of lower molars in some Marsupials, Insectivora, and Chiroptera, are the most ancient elements of the mammalian molar; he identified their homologues, or worked out their fate, in the teeth of other mammalian orders. Two other cusps, internal in upper, external in lower teeth to cusps 1, 2, and 3, were regarded by Winge as later additions, and were numbered as 4 and 5. Here, according to Winge, the development of the lower molars stopped; but in the upper teeth, internally to cusps 4 and 5, two new ones, 6 and 7, successively appeared. In his great papers on the *Lagomorpha* (*Trans. Linn. Soc., Zool.* [2], vii., 433, Nov. 1899), and on the genus *Brachyuromys* (*Proc. Zool. Soc.*, 1897, 695), Forsyth Major adopted Winge's notation for the cusps of upper molars; but he recognised the fact that the evolution of the lower molars is in a *more* and not a *less* advanced stage than is that of the upper teeth—a result confirmed by Stehlin's researches upon the dentition of the pigs (*Abhand. Schweiz. Palæont. Gesellsch.*, xxvi., 22 *et seq.*, 1899). Forsyth Major was therefore able to identify in lower molars the homologues of the cusps 6 and 7 of the upper ones; in addition he took into account some other elements not recognised by Winge, viz., the "intermediate" tubercles.

It has long been known that the inner and outer sides of upper molars correspond respectively with the outer and inner sides of the lower teeth; Fleischmann (*Sitzungsber. Preuss. Akad. Wiss. Berlin*, 1891, ii., 891) went a step further and asserted that the anterior and posterior ends of upper molars are respectively homologous with the posterior and anterior ends of the lower cheek-teeth; a lower molar is therefore a completely inverted image of an upper one. This view was contested by Osborn (*Bull. Amer. Mus. Nat. Hist.*, 1892, 84), but it has been endorsed by Forsyth Major (*Proc. Zool. Soc.*, 1893, 201), and it is supported by Hinton's work. Forsyth Major thought that the cheek-teeth of rodents were derived by a process of simplification or reduction from a multituberculate prototype, and in this he is followed by von Méhely and Hinton. The latter, in his system of cusp notation, takes notice of some ancient elements of the rodent molar which, hitherto, have escaped recognition, and gives effect to the results of all the work briefly reviewed above.

upper cheek-teeth of *Cricetinæ* (see above, p. 383) have but two rows of tubercles, but in their case the absence of a distinct third row is due apparently to the slight development of the median series, and not to a reduction of the inner row (Pl. XXVIII., Fig. 1).

The presence of these three rows of tubercles in the upper molars of *Murinæ* is a fact of high zoological interest, and has given rise to much discussion. Some authors such as Tullberg (*Nagethiere*, 1899, 446) have regarded the inner row as a new addition to the mammalian molar. Winge (*Vid. Med. Nat. For. Kjöb.*, 1881, 17, and 1882, pl. iii., fig. 10*b*), on the other hand, homologises two of the inner tubercles with the cusps, which he numbers as "6" and "7"[1] or the equivalents of the "proto-" and "hypo-cones" of trituberculy; he regards the median and outer rows as simply the result of cleavage of the outer tubercles which are normally present in mammalian molars but which have been specially enlarged in those of *Murinæ*. What, for reasons which cannot be discussed here, is probably the correct view of this latter matter has been put forward independently by Osborn (*Proc. Amer. Assoc. Adv. Sci.*, xlii., 203, 1893) and Forsyth Major (*Proc. Zool. Soc.*, 1897, 714); these regard the median row of tubercles as the enlarged representatives of those molar elements which in other placentals are called "intermediate" cusps, which comprise the "proto-" and "meta-conules" of trituberculy. Both writers thus agree with Winge that the inner row comprises ancient and normal elements of the mammalian molar. Winge regards the postero-internal tubercle of the m^1 of *Apodemus* (Pl. XXVIII., Figs. 4-6, "7") merely as a new offshoot from the postero-median tubercle—*his* cusp "5"; but Thomas (*Ann. and Mag. Nat. Hist.*, January 1906, 84) has argued with right that, occurring as it does not only in *Apodemus* but in many quite distinct murine genera now isolated in such remote corners of the Old World as Australia, the Philippines, Celebes, New Guinea, and Africa, this tubercle must be regarded as an ancient element also, and not as a new addition; and Hinton now homologises it with the cusp which, in the teeth of *Microtinæ*, is numbered by Winge himself as "7" (Pl. XXVIII., *cf.* Figs. 2-7). This view

[1] These are the cusps numbered x' and 6 respectively in Pl. XXVIII., Figs. 4-10*a*.

is in complete accord with the results obtained in *Microtinæ*, where in addition to cusp 7 other ancient elements (n, n^1) are sometimes present though they have not yet been found in the teeth of living *Murinæ*. The results in question fully support the theory of a multitubercular origin of the rodent cheek-tooth postulated by Forsyth Major, and are in complete conflict with the tritubercular theory of Cope and Osborn.

The lower cheek-teeth are in one way more modified than the upper ones; the outer row of tubercles corresponding to the inner row of the upper teeth is so reduced that it has been either completely ignored or else treated as a mere cingulum by all writers except Tullberg. In *Apodemus* and many exotic genera this third row is comparatively well-developed, and consists normally of three tubercles in m_1; it has, on the other hand, completely vanished from the teeth of *Mus* and many other genera; throughout the sub-family it shows the high degree of variability which is characteristic of vanishing structures. From the circumstance that it is a marked feature of the teeth of *Apodemus* and some other *Murinæ*, that it forms an important part of the teeth of some *Microtinæ*, e.g. *Dicrostonyx* (Pl. XXVIII., Fig. 2), and occurs ephemerally in the young teeth of still more remote relatives, e.g. *Spalax* (Méhely, *Species Generis Spalax*, 1913, 305, fig. 10), and from the fact that it comprises such ancient and well-known molar elements as the "proto-" and "hypoconids" of trituberculy, we may conclude that this third or outer row of tubercles was an important feature in the lower molars of the ancestral *Muridæ*. It has suffered reduction and even obliteration in consequence of the hypertrophy of the "intermediate" cusps of the teeth of these remarkable rodents.

Two other elements of the lower cheek-teeth deserve notice. In m_1 and m_2 a posterior "accessory" tubercle (Pl. XXVIII., Figs. 4-10) is almost constantly present in *Murinæ;* this structure appears to be the homologue of part of the posterior transverse loop of the corresponding teeth in *Microtinæ*. In most species of *Apodemus*, and in some other murines, m_1 has an anterior "accessory" tubercle which appears to represent the anterior loop of the m_1 of *Microtus*.

Because of their forward position in the jaws the greater share of the work of mastication falls upon the anterior cheek-

teeth above and below, and therefore throughout the sub-family (as in other *Muridæ*) $m\frac{1}{1}$ are the largest and most complex or conservative teeth of the series; $m\frac{2}{2}$ are much smaller, and certain of the cusps, present in the forward part of m_1, are not developed; because of their posterior position and consequent slight mechanical importance $m\frac{3}{3}$ are greatly reduced both in size and in the number of their constituent tubercles, and in several murines these teeth are even entirely suppressed.

The skin of the **tail** becomes detached very readily in some species, *e.g.* in *Apodemus sylvaticus*, being, perhaps, like the brittle tail of dormice (see above, ii., 350), a safeguard against capture by enemies.[1] A mouse which has "escaped by the skin of its tail" generally eats down the injured appendage until it reaches the point where the skin parted.

The sub-family contains, according to Miller, about fifty described genera, four of which occur in Britain. Its members are **distributed** naturally throughout the Old World, with the exception of Madagascar and New Zealand; species of the genera *Epimys* and *Mus* have, as parasites upon humanity, acquired a secondary distribution of world-wide exent.

Murinæ are first known from the Upper Miocene of Europe, and the Pliocene of India; they must have **originated** in the Old World somewhere to the south of the temperate regions, reaching the latter too late to find their way to North America.

Genus APODEMUS.

1829. Apodemus, Jakob Kaup, *System der Europaischen Thierwelt*, i., 150 and 154; based on *Mus agrarius* of Pallas, *Novæ Species Quad. e Glirium*, 1779, 95, described from Berlin, Germany; Thomas, *Ann. and Mag. Nat. Hist.*, May 1908, 447 (part); Miller, *Catalogue*.

1905. Micromys, Oldfield Thomas, *Ann. and Mag. Nat. Hist.*, May 1905, 492 (part).

Mus of most writers prior to Thomas, 1905, quoted above.

Synonymy and classification:—The subdivision of the large

[1] Some exotic *Murinæ*, e.g. *Acomys* (see Bate, *Ann. and Mag. Nat. Hist.*, June 1903, 566), have also very brittle tails, but this does not seem to be the case with any British species.

and unwieldy genus *Mus* is a constant object of systematists. Most recent arrangements seem to have originated with Hensel, who in 1856 (*Zeitschr. deutsch. geol. Gesellsch.*, viii., 289) formed two groups, one containing *norvegicus*, *rattus*, and *musculus*, the other *sylvaticus*, *agrarius*, and *minutus*. Hensel's work, although much neglected or overlooked, was supported by Forsyth Major in 1884 (*Atti Soc. Tosc. Proc. Verb.*, iv., 129) and Thomas in 1905, the latter using *Micromys* to include *sylvaticus*, *speciosus*, *minutus*, *mystacinus*, *agrarius*, *harti*, and *geisha*. In 1908 Thomas substituted the earlier *Apodemus* for *Micromys*, and in 1912 Miller restricted the name to *agrarius*, *sylvaticus*, *epimelas*, and their allies, the genus *Micromys* being restricted to the Harvest Mouse (*Mus minutus* of Pallas) and its allies.

Characters:—The mice of this genus are rather generalised, and not markedly modified by specialisation in any particular direction. Their ears have no special meatal valves : their tail is not prehensile. They have six or eight mammæ, of which two pairs are inguinal, and one or two pairs pectoral. Their skull has the rostrum well developed, so that, unlike that of *Micromys*, the diastema is distinctly longer than the cranial depth at the anterior root of m^1; the palatal shelf is squarely or roundly notched behind by the posterior nares, though sometimes provided with a short central spinous process ; m^1 and m^2 are complex, having three cusps on their inner sides (Pl. XXVIII., Figs. 4-6, x', 6, 7).

The genus is widely **distributed** in arctic, boreal, and transitional regions of the Old World, from Ireland to Japan, and from northern Skandinavia and corresponding latitudes to the Barbary States of North Africa, Palestine, Persia, and northern India. It is absent from Kamtschatka. It is first known from the late Pliocene (Forest Bed) of England, and is evidently of Old World **origin**.

The complexity of the cheek-teeth is a primitive character which assigns to *Apodemus* the lowest **status** among European *Murinæ*. The combination of such cheek-teeth, non-prehensile tail, and normal skull is quite distinctive amongst Palæarctic genera, and is not exhibited by any Oriental or Australian species. Some African mice (*Thamnomys*, Thomas, *Ann. and*

Mag. Nat. Hist., January 1907, 121), however, show a similar combination of characters, perhaps indicating relationship with *Apodemus*, but for Eurasian mammals the genus is a useful and practical institution.

Although not apparently capable of wide variation from the generic type, these mice show, nevertheless, great plasticity before the moulding influences of their environment. Considering the wide range of the genus, the number of its **species** is relatively few; but most of these species are differentiated into numerous sub-species, which are to be regarded as purely local developments or adaptations. The characters which betray this plasticity are principally those of the pelage, coloration, and the proportions of the peripheral organs; the size and form of the skull, and, to a lesser degree, of the teeth are also subject to local modification.

In the **A. sylvaticus** group, to which all the British forms belong, the fur is typically soft, the darker hairs of the back are diffusely distributed and mingled with lighter ones, and the general colour of the upper parts is russet or tawny in more or less sharp contrast with the light belly. The ears, tail, and limbs, particularly the feet, are relatively long. There are six mammæ, the anterior pectoral pair being absent. The skull is always without supra-orbital beads. The cheek-teeth have the outer and inner rows of tubercles relatively well developed; cusp 1 is present in both m^1 and m^2; cusp 7 is well developed in m^3; the outer "accessories" of m_1 are rather large and include vestiges of cusps 6, 7, and *n*. The British representatives of this group are:—

A. sylvaticus, Britain, Ireland, and many of the smaller islands (including Skye and Bute).
A. hebridensis, Hebrides (exclusive of Skye and Bute).
A. hirtensis, St Kilda.
A. fridariensis, Fair Isle and Mid Yell, Shetlands.
A. flavicollis, South Britain.

Of these forms *A. sylvaticus* shows a tendency to split up into several local races or sub-species within the British area. *A. hebridensis*, *hirtensis*, and *fridariensis* may be regarded as local developments from the primitive *sylvaticus* stock of the region, which appear to have resulted from the segregation of this stock upon small islands; the characters which distinguish them from the parent stock are slight, and all three might well be regarded as mere sub-species of *sylvaticus* were it not for the fact that *hebridensis* and *fridariensis* have in turn undergone a further differentiation into a number of quite recognisable and

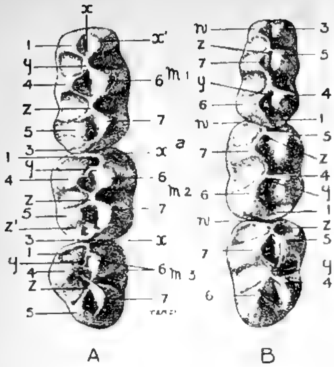


FIG. 1.

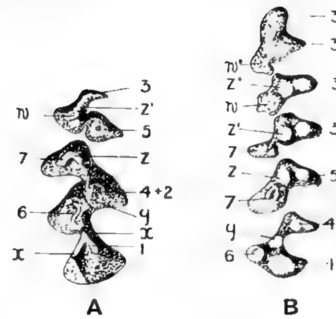


FIG. 2.

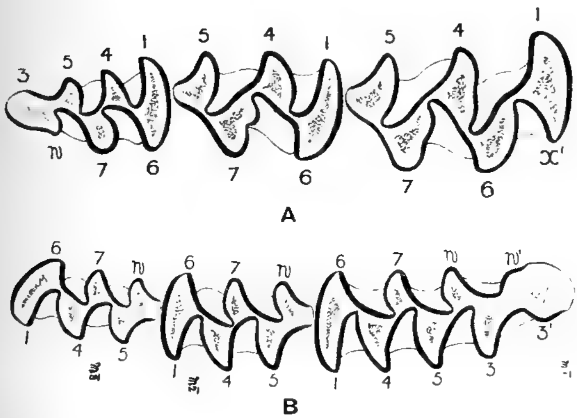


FIG. 3.

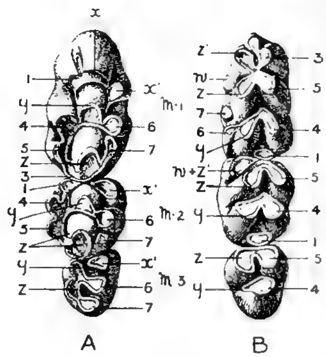


FIG. 5.

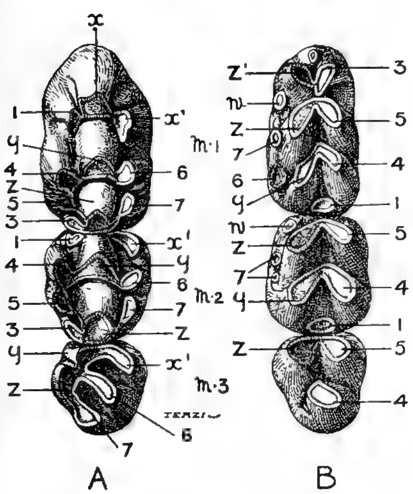


FIG. 4.

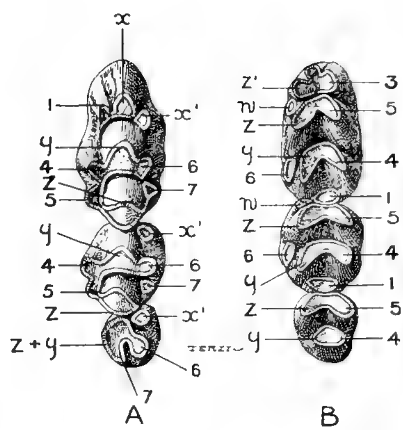


FIG. 6.

For explanation of Figures, see overleaf.

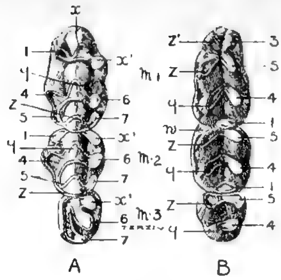


FIG. 7.

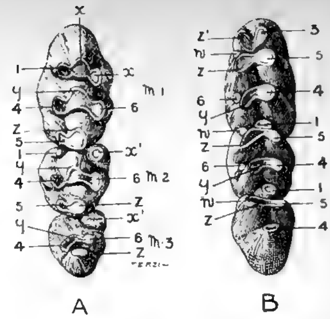


FIG. 8.

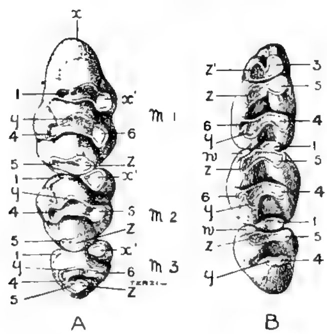


FIG. 9.

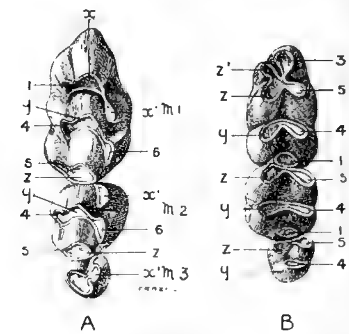


FIG. 10.

EXPLANATION OF FIGURES.

CROWN VIEWS OF SLIGHTLY WORN CHEEK-TEETH OF MURIDÆ.

a, RIGHT UPPER TEETH ; *b*, LEFT LOWER TEETH.

All the figures, with the exception of Figs. 2 and 3, *are from Miller's "Catalogue of the Mammals of Western Europe" (by kind permission of the Trustees of the British Museum).*

Fig. 1.—*Cricetus cricetus* (five times life size).
,, 2.—*Dicrostonyx* sp., m^1 and m_1 (ten times life size), of a very young animal from Floeberg Beach, Grinnell Land (B. M., 78.5.13.1).
,, 3.—*Arvicola amphibius* (seven times life size).
,, 4.—*Apodemus epimelas* (ten times life size).
,, 5.—*Apodemus sylvaticus* (ten times life size).
,, 6.—*Apodemus agrarius* (ten times life size).
,, 7.—*Micromys minutus* (ten times life size).
,, 8.—*Epimys rattus* (five times life size).
,, 9.—*Epimys norvegicus* (five times life size).
,, 10.—*Mus musculus* (ten times life size).

The homologous cusps of upper and lower cheek-teeth are similarly lettered or numbered in the figures. In upper teeth cusp 6 equals the "protocone" of trituberculy (*cf.* Vol. I., Pl. II., Fig. 1A) ; 7 is the "hypocone" ; 4 and 5 are the "para-" and "meta-cones" ; 1 and 3 are the "para-" and "meta-styles" ; and *y* and *z* are the "proto-" and "meta-conules" respectively. In the microtine tooth (Fig. 2*a*) the cusps marked 4, 5, 6, and 7 correspond with those so numbered by Winge in upper teeth of *Evotomys* and *Microtus* (*Danmarks Pattedyr*, pp. 70, 77, Figs. 27*b*, 30*b*). In *Murinæ*, Winge regards the cusps here called x^1 and 6 as the homologues of 6 and 7 in the *Microtinæ ;* he further regards *y* as the major part of 4, and similarly his cusp 5 in this sub-family is a compound of the cusps 5, *z*, 3, and 7 (see *Vid. Medd. Nat. For. Kjöb*, 1882, Pl. iii., Fig. 10*b*, and *Danmarks Pattedyr*, pp. 86, 93, Figs. 33*b*, 42*b*). The view of the homologies expressed in this plate has been gradually arrived at in the course of many years' work upon the dentition of rodents, and with a knowledge of many facts which cannot be discussed here.

The ancient cusp 2 (Vol. I., Plate II., Fig. 1A, *ms*) which, according to Winge, is the homologue of the Reptilian cone, and is, therefore, the true "protocone," is present in the teeth of many low *Muridæ*, e.g. some of the American *Cricetinæ* and the Malagasy *Nesomyinæ* ; in all *Microtinæ* and *Murinæ* 2 has fused with cusp 4, and has completely disappeared.

histories of very many others, which were formerly little known, have been fully elucidated, while, speaking generally, an immense increase in our knowledge on such important subjects as Migration, Distribution, Habits, Nidification, Plumages, has accrued: And lastly, a new and important branch of study has been instituted—namely, the recognition of the various Racial Forms or Subspecies exhibited by certain birds in the British Islands, on the Continent, and elsewhere.

A great advance has also been made towards a more satisfactory system of classification of the Aves—always a difficult subject—and this necessitates departures from the older views.

To bring this Standard Work thoroughly abreast of the most recent knowledge in all these departments is the object of the present work.

It should be remarked that while it is not intended to go fully into Synonomy, yet, where changes of nomenclature have been necessary in order to conform with the Law of Priority—the only method by which complete uniformity in nomenclature can ultimately be attained—the names used in the Fourth Edition of Yarrell's "British Birds" and in Saunders' "Manual," and the Trinomial Names of the British Racial Forms, and of those occurring in Britain as visitors from the Continent, will be quoted, as will also the Original Name under which the species was described.

In requesting Mr Eagle Clarke to undertake the duties of Editorship, the Publishers desire to make it known that they are acting under the advice of the late Mr Howard Saunders, who placed all his collected notes for a New Edition at Mr Eagle Clarke's disposal for this purpose. That Mr Eagle Clarke is eminently fitted for the work is well known to all who are interested in ornithological science. Through his investigations of the subject, and contributions to its literature, he has long been recognised as one of the foremost authorities on all that relates to British birds. He has studied our native birds in many portions of the British Islands, and has visited a number of bird-haunts in various parts of Europe in order to become acquainted in their Continental homes with the visitants that seek our shores.

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A HISTORY OF BRITISH MAMMALS

BY

GERALD E. H. BARRETT-HAMILTON

B.A. (CANTAB.), M.R.I.A., F.Z.S.

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A NEW AND REVISED EDITION OF
YARRELL, NEWTON, AND SAUNDERS'

HISTORY OF BRITISH BIRDS

EDITED BY

WILLIAM EAGLE CLARKE, F.R.S.E., F.L.S.

Keeper of the Natural History Department, The Royal Scottish Museum; Member of the British Association Committee on the Migration of Birds as Observed on the British and Irish Coasts; Corresponding Fellow of the American Ornithologists' Union; Correspondirender Mitglied des Ornithologischen Vereins in Wien; Membre Honoraire du Bureau Central Ornithologique Hongrois; Member of the British Ornithologists' Union, etc.

ILLUSTRATED BY ORIGINAL COLOURED PLATES OF EACH SPECIES SPECIALLY EXECUTED BY

MISS LILIAN MEDLAND

THE publication of Yarrell's "History of British Birds" was commenced in 1837 and completed in 1843. Its outstanding merits were at once recognised, and a Second Edition was called for in 1845, followed by a third in 1856.

From the issue of the Original Edition down to the present day, Yarrell's "History of British Birds" has generally and deservedly been regarded as the standard authority on British ornithology.

In the year 1871 a Fourth Edition was begun, under the masterly editorship of Professor Newton—the greatest British ornithologist of all time. Unfortunately Professor Newton's official engagements at the University of Cambridge only allowed him to complete the first two volumes; and in 1882 Mr Howard Saunders was selected to edit the remaining volumes, a task which he successfully accomplished to the entire satisfaction of ornithologists in 1885.

The many excellences of this last edition advanced the work more than ever in the public and in scientific favour. To its stimulating influence is to be mainly attributed the marvellous and unprecedented activity which has resulted in those extraordinary advances made in all branches of British ornithology during recent years—advances which have rendered it essential that a new work based upon this classical and comprehensive foundation should be issued.

During the period alluded to, a considerable number of new and interesting species have been added to our avifauna. The

[*Continued on Page 3 of Cover*

CONTENTS OF PART XVII.

The English local names have been revised in part by Mr W. W. Skeat, M.A. (assisted by the late Professor W. W. Skeat), and in part by Mr C. M. Drennan, M.A. Lond., late Scholar Emm. Coll. Camb.; the Celtic and Gaelic names by Dr E. S. Quiggin, M.A., Ph.D., Fellow and Lecturer in Modern Languages and Celtic of Gonville and Caius College, Cambridge; while a list of Scottish Gaelic names has been supplied by Mr C. H. Alston. Much information has been taken from Mr G. S. Miller's recently published "Catalogue of the Mammals of Western Europe," the use of the MS. and proofs of which before publication was kindly permitted by the Trustees of the British Museum of Natural History.

ILLUSTRATIONS

FULL-PAGE (*Black and White*).

FIGURES IN TEXT.

distinct insular races. *A. flavicollis* appears to be a specialised offshoot of the *sylvaticus* group; it is quite likely of Eastern origin, its range extending from northern India to England, in which latter country it is a relatively recent immigrant and has developed as a sub-species, *A. f. wintoni*, distinct from the typical continental form.

The *sylvaticus* group has a wide range, extending over the whole habitat of the genus with the exception of eastern Asia and Japan. This group probably originated in western Europe; it is first known from the late Pliocene (Forest Bed) of Britain, and all the fossil forms hitherto discovered in this country are close allies of *A. sylvaticus.*

A. mystacinus, Danford and Alston (*Proc. Zool. Soc.*, 1877, 279), from Palestine, and *A. epimelas*, Nehring (*Sitz.-Ber. Gesellsch. Nat. Freunde, Berlin*, January 1902, 2), from Greece and the Balkan Peninsula, are much like the *sylvaticus* group in essentials, but differ in their large size and rather more primitive molars, m^1 and m^2 retaining a distinct cusp 3—an ancient element of which no more than the merest trace is normally present in other known species of *Apodemus* (Pl. XXVIII., Fig. 4).

A. geisha, Thomas (*Ann. and Mag. Nat. Hist.*, May 1905, 491), is confined to the Japanese Archipelago, where its typical form occurs on Hondo, Shikoku, and Kiushiu; it is differentiated into distinct sub-species on each of several of the islands to the north or south of the three named. It is described as a delicate species about equal in size to one of the smaller forms of *A. sylvaticus*, but with more of the build and appearance of a large harvest mouse; its soft fur does not become spiny in summer; it has eight mammæ; the skull is very smooth, light and delicate, without supra-orbital beads, and with the masseteric zygomatic plates but little developed; cusp 1 is present in m^2.

A. speciosus, Temminck (*Fauna Japonica*, 1845, 52; described from Japan), is the type of a widely distributed Eastern group which ranges throughout Japan, Korea, Manchuria, and westwards and southwards through China; in central Asia it is represented by *A. nigritalus*, Hollister (*Smiths. Misc. Coll.*, March 1913, 1; described from Tapucha, Altai Mountains, S.E. of Biisk), and it is there accompanied by a member of the *sylvaticus* group (*A. s. tscherga*, Kastchenko). In the *speciosus* group the fur becomes spiny in summer, and there are eight mammæ; the skull has the margins of the inter-orbital region beaded; the cheek-teeth are like those of the *sylvaticus* group. *A. semotus*, Thomas (*Ann. and Mag. Nat. Hist.*, May 1908, 447), is an interesting representative of the *speciosus* group inhabiting the island of Formosa; this is a dark-coloured, thin-furred form which has lost the anterior pectoral mammæ, there being but six as in *A. sylvaticus*, and in which m^1 and m^2 have cusp 7 better developed than in most of the sub-species of *speciosus.*

A. agrarius, Pallas (*Nov. Sp. Quad. e Glir.*, 1778, 95; described from Berlin), the "Brandmaus," is a species with a very wide range, extending from Denmark and Germany across Eurasia to the coast of China and Korea; it is also known to inhabit some of the Asiatic coastal islands, such as Quelpart, but it does not reach Japan; its absence from Britain, Skandinavia, and Iberia is noteworthy. In its typical form this species is characterised by the ochraceous colour of the upper parts, and the middle of the back is clothed with black hairs which form a sharply defined dorsal streak. The tail, ears, and feet are relatively short, and the general form is stouter than in the *sylvaticus* group; there are eight mammæ. The skull has supra-orbital beads as in *A. speciosus*. The cheek-teeth (Pl. XXVIII., Fig. 6) are more highly specialised than are those of other species of *Apodemus*: the median tubercles of the upper teeth are much enlarged at the expense of the outer and inner rows; cusp 1 is much reduced in m^1 and has vanished from m^2; cusp 7 is reduced in m^3. This group has not improbably originated in the East, and it may well be the result of a specialisation of the same stock as that from which *A. speciosus* has descended. In this connection it may be noted that in *A. chevrieri*, Milne-Edwardes (*Rech. Mamm.*, 1868, 288; described from eastern Thibet), a close ally of *A. agrarius*, the fur develops spines in the summer and there is no trace of dorsal darkening. In the Chinese *A. a. ningpoensis*, Swinhoe (*Proc. Zool. Soc.*, 1870, 637), there is little trace of the dorsal streak, while in *A. a. coreæ*, Thomas (*Proc. Zool. Soc.*, 1908, 8; described from Korea and Quelpart Island), it is subject to great variation, and the summer coat is spiny. Other far-eastern sub-species, *A. a. mantchuricus*, Thomas (*Proc. Zool. Soc.*, 1898, 774), and *A. a. pallidior*, Thomas (*Proc. Zool. Soc.*, 1908, 8; described from the Shantung Peninsula), resemble the European *A. agrarius* in these respects.

THE FIELD MOUSE.[1]

APODEMUS SYLVATICUS (Linnæus).

APODEMUS SYLVATICUS SYLVATICUS (Linnæus).

1758. [MUS] SYLVATICUS, Carolus Linnæus, *Systema Naturæ*, 10th ed., 62; described from Upsala, Sweden; Fleming; Jenyns; Bell (ed. 1 and 2); Turton and practically all authors, except as given below.

1839. MUS INTERMEDIUS, J. C. Bellamy, *Natural History of South Devon*, 195 and 329, and figure; described from Whiteford stables, Devonport, Devonshire.

1900. MUS SYLVATICUS INTERMEDIUS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 398; Johnston; Millais; Trouessart.

[1] Long-tailed Field Mouse or Wood Mouse of some authors.

1900. MUS SYLVATICUS CELTICUS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 401, pl. xxv., fig. 2; described from Caragh Lake, Co. Kerry, Ireland, and based on an immature specimen of *M. s. sylvaticus;* (type a female, No. 0.3.11.1 of Brit. Mus. collection, taken by Colonel J. W. Yerbury, 27th November 1894); Johnston; Millais; Trouessart.

1900. MUS SYLVATICUS TYPICUS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 404.

Skovmus of the Norwegians; *le mulot* of the French; *die Waldmaus* of the Germans.

Synonymy:—The first item refers to the species *sylvaticus;* the remainder to the well-known sub-species common in Britain. As this species is also widely distributed in Continental Europe, it has received many names, but only those referring to British specimens are cited. The full synonymy will be found in Miller's *Catalogue.*

The British synonymy is simple. Unfortunately the common British Field Mouse was at one time considered a recognisable form, for which Bellamy's name *intermedius* became available, but Miller has shown that that is not the case. Unfortunately also, *A. s. celticus* cannot be retained as a distinct form. The synonymy and description of valid local forms is given separately below.

Terminology:—This mouse, the *Mus domesticus medius* of Ray (1693), appears in the earlier subsequent natural histories (Pennant, 1766 and 1768; Berkenhout, 1769) as the "Long-tailed Field Mouse," a term used in opposition to the "Short-tailed Field Mouse" (*Microtus*). In his edition of 1776 Pennant shortened this name to "Field Mouse." He was followed by Fleming and Jenyns; but the longer term was retained as an alternative by Bingley (1809), and exclusively by Donovan (1815-1820). "Wood Mouse," which is evidently a translation of the Latin specific name *sylvaticus*, appeared first in Turton (1807), disappeared until 1837, when it was revived as an alternative, by Bell, from whom it was adopted by practically all subsequent writers, though sometimes with the longer name as an alternative, except Johnston (1903), who reverted to "Long-tailed Field Mouse." The latter term has become too long to apply to all the forms now recognised as distinct from *sylvaticus*, but if the adjective "long-tailed" be dropped, the oldest name for the animal in British zoology thus abbreviated becomes also the most appropriate, "Field Mouse" having its older significance of "Wild" or "Out-of-door Mouse" in contrast to "House Mouse." The name "Wood Mouse," although short, is not nearly so appropriate, the common *sylvaticus* being found in a wide range of habitats.

Local names (non-Celtic):—Many of the names of other animals, *e.g.* shrew and dormouse, are sometimes applied indiscriminately to mice regardless of species. Thus when found in a bird's nest the

Field Mouse may pass for the Dormouse (see Bolam, *Naturalist*, 1913, 41). "Bean Mouse" (sometimes "Beaner") of Pennant (Thompson, iv., 1856, 15) is a word known in Kent, Surrey, and Sussex, from its habit of attacking stores of beans and peas (L. E. Adams, *MS.*).

(Celtic):—Scottish Gaelic—the species of mice are not usually distintinguished, and *luch-fheoir* or *luch-an-fheoir*="grass mouse" is applied indiscriminately in Scottish Gaelic (C. H. Alston). Irish—*Luch fheoir*="grass mouse" of Clare Island (Colgan, *Proc. R. Irish Acad.*, xxxi., 4, 22, 1911). Welsh—*Llygoden y maes* or *Llygoden goch*=Field Mouse; *Llygoden ganolig*=Common Mouse. Manx—*Lughvarghey*, *Lugh sliean* (Millais).

History and status:—A species of *Apodemus* was described by Gesner (*Quad.*, 1551, 830) as *Mus agrestis major*. Although many descriptions were published in the eighteenth and the early part of the nineteenth centuries, a knowledge of the status of these mice cannot be said to have existed prior to the work of Hensel (1856). The status has been discussed above under the genus.

Distribution:—*A. sylvaticus* is distributed over nearly the whole of Europe and a large part of Asia. Its range extends from Ireland and Iceland to central Asia, and from central Skandinavia and northern Russia southwards to Algiers, Sicily, Crete, the mountains of southern Persia, and northern India. In the Alps, according to Blasius, it ascends to 6000 feet. Fatio (p. 212) records it from a height of 1900 metres in the Bernese Oberland, and from 2500 metres in the Engadine[1]: he says that in the bad season it retires from such stations to chalets and the cellars of houses. In the Altai Mountains it is met with up to about 7000 feet; in the mountains of Persia it has been taken at about 5000 feet; and it occurs in the Himalayas up to a height of 11,500 feet.

Miller says: "This is the most abundant and universally distributed of European mammals. Except in cities, at the extreme north, on the highest mountains, and perhaps in some parts of the Mediterranean region, it is probably more numerously represented in individuals than any other species."

The typical sub-species, *A. s. sylvaticus*, which is the common British form, ranges from Ireland across central Europe eastwards for an unknown distance into Russia; and from central Sweden and Norway to the south of France and northern Italy. It occurs also in Iceland, but is generally regarded as an introduction there. Thienemann (*Reise im Norden Europas*, ii., 153) described the Icelandic Field Mouse as a distinct species, *Mus islandicus*, but in habits and character this animal does not appear to differ from typical *sylvaticus* (see Steenstrup,

[1] These high Alpine Mice were probably *flavicollis*, see p. 546 below.

Vid. Med. Nat. For. Kjöb., 1868, 51; Brown, *Proc. Zool. Soc.*, 1868, 343; Miller, *Catalogue*, 804).

In Britain it is probably, with *Sorex araneus*, the commonest small British mammal, of practically universal distribution; both species are very common in owl's pellets, their numbers being only approached in certain situations by the Grass Mouse, which (Coward and Oldham, *Cheshire*, 273), although preponderating in certain limited areas, is not nearly so widely distributed as the Shrew and Field Mouse. The Bank Mouse is numerous, but also cannot compete with these two (Pocock, *Zoologist*, 1897, 507; Grabham, *ibid.*, 571). Traces of "a colony of some small animals" on the top of Maam Soul, Inverness-shire, at a height of between 3000 and 4000 feet, noticed by the Rev. G. Gordon (*Zoologist*, 1844, 424; A. Hepburn, *ibid.*, 1848, 2010), may possibly refer to this species, but as W. Evans (*in lit.*) points out, the "small animals are more likely to have been 'voles' of some sort." In the Edinburgh district, according to W. Evans, it is common from sea-level to a considerable elevation in woods, fields, and natural pastures, but is more numerous in the plains and warmer valleys than in the damp uplands beloved of *Microtus*.

It is of widespread though less common occurrence in Ireland, and inhabits the islands off the west coast such as Inishmore and Clare. It occurs on Man, Anglesey, Bardsey, Lundy, Skomer, Lambay, Scilly, Wight, and the Channel Islands: it is common on Skye and Bute, but on the latter island its differentiation from the typical form has proceeded so far that it is now given distinct sub-specific rank. Field Mice inhabit Orkney (Barry, ed. ii., 1808), and a form much like typical *sylvaticus* occurs on the mainland of Shetland. Ogilvie-Grant has recently caught specimens of a long-tailed, rather pallid form on Sanday, Orkney; these were taken among the rough grass by the sea. The precise status of the Sanday Field Mouse cannot be settled without further material, but, judging from the skull, it is more nearly related to *sylvaticus* than to *fridariensis*.

Distribution in time:—The *A. sylvaticus* group dates from the late Pliocene (Forest Bed of Norfolk) in Britain, and in the earlier part of the Pleistocene it is known from the High Terrace and the older deposits of the Middle Terrace of the Thames. These older fossils are for the most part very fragmentary, and they prove little more than that the teeth of the earliest British Field Mice were similar in size and form to those of *A. sylvaticus* (Newton, *Vert. Forest Bed*, pl. xiv., fig. 11, a). A maxilla from the High Terrace, at Greenhithe, Kent, shows that in the skull of the form of this horizon (*A. whitei*, Hinton, *Ann. and Mag. Nat. Hist.*, June 1915, 580) the posterior ends of the incisive foramina and the maxillo-palatine suture were a little more forwardly placed than in existing races. The Forest Bed and Middle Terrace forms may eventually prove to belong to *A. whitei* also.

Like the older forms of *Evotomys*, the *Microtus agrestis* group and

Arvicola, Apodemus appears to have died out in Britain during the middle Pleistocene, no trace of the genus being found in the later deposits of the Middle Terrace of the Thames. It then reappeared in the late Pleistocene (Ightham stage) by two forms having close affinities with the living *sylvaticus* and *flavicollis* respectively. The *sylvaticus*-like form has been discovered in numerous English cave and fissure deposits of late Pleistocene age; but the remains, although abundant, are not sufficiently perfect to permit of a close comparison with any particular one of the living British members of the group. In Ireland similar fossils have been obtained from the Ballinamintra Cave, Co. Waterford (Adams, *Trans. R. Dublin Soc.*, S. 2, vol. l., 195, 1881, where they are described as frog bones; see Scharff, 184); the caves of Kesh, Co. Sligo, where they were found in all deposits from the superficial brown layer to the basal clay (Scharff, 197); the Edenvale Caves, Co. Clare, where they were fairly abundant in all the caves, both in upper and lower strata (Scharff, 35); and the Newhall and Barntick Caves, Co. Clare, where they were rare and occurred mainly in the upper strata (Scharff, 35). Remains of *A. sylvaticus* are also common in Holocene alluvial deposits and "submerged forests" in England.

Description:—In general form the Field Mouse is much like a House Mouse, but differs in its much longer hind legs, larger hind feet and ears, and in its much larger and far more prominent eyes.

The ears are of a broad ovate form, and extend, when laid forwards, for a short distance beyond the eyes; they are thinly clad with short hairs; the antitragus is represented merely by a feeble ridge. The tail is about equal to the head and body in length; it tapers distally, is somewhat angular in section, and distinctly annulated, there being about 150 rings in all; the tail hairs are short and do not conceal the annulations, though they form a short terminal pencil. The snout is long and very prominent; the nostrils, separated by an upward continuation of the deep median cleft of the lip, open obliquely outwards and forwards, and are wider in front than behind; beneath them the small naked muzzle-pad is bounded by a transverse furrow. In each hand the thumb is a rudimentary tubercle covered by a small nail; digits 2, 3, and 4 are the longest, 3 is slightly longer, 2 distinctly shorter than 4; digit 5 reaches to the base of 4; each finger is armed with a small sharp claw and crossed below by deep transverse grooves, of which there are five or six on digit 3; the palm is naked and provided with five normally placed pads, of which the two hinder are the largest; between the pads the skin is irregularly wrinkled. In each foot the hallux extends to the base of digit 2; the three middle toes are of nearly equal length, digit 3 being, however, slightly the longest; digit 5 reaches distinctly beyond the base of digit 4; the toes are grooved transversely below, there being seven or eight grooves on the central digits; their claws are like those of the fingers. The sole is

naked except in the region of the heel, and it is provided with six normally placed pads; the latter though well developed are smaller than those of the palm; they are ovate in form, the postero-external being the smallest; the skin between the pads is finely tuberculo-reticulate, smooth between the last pad and the heel, in which latter situation it is wrinkled. There are six mammæ in the female, one pair being pectoral, the remaining two pairs inguinal. In young males the *glans penis* is complex; the parts called *papilla centralis*, *pp. laterales*, and *p. lingualis* by Tullberg being distinct, as in *Cricetus;* in the adult certain of these elements fuse together, and the *glans* acquires a simpler form approaching that of higher *Murinæ*, e.g. *Epimys* (see Hinton, *Ann. and Mag. Nat. Hist.*, July 1914, 133). Each testis when fully developed is as large as, or larger than, the brain.

Pelage:—The fur is soft and never becomes spinous, for though many of the hairs of the back are grooved bristles these are quite weak. The density and length of the fur varies according to the sub-species, age, or season. In English specimens the longer hairs of the back attain a length of about 9 mm. in summer, and 10 mm. in winter.

Colour (*A. s. sylvaticus*):—The basal two-thirds of all hairs, at all ages and seasons, are slate-grey; this tint is concealed by the differently coloured hair tips. The general colour of the back in adults in fresh pelage is "wood-brown," with a more or less distinct reddish tinge posteriorly, and becoming paler or more buffy on the head, shoulders, and flanks. Numerous long black hairs slightly but distinctly cloud the middle of the back with black; on the flanks, where they are fewer, these hairs produce a well-marked "lining" effect. On the cheeks, sides of the neck, outer surfaces of the fore legs, and along a narrow, ill-defined region immediately above the line of demarcation on each side, the colour is a dull light buff. The line of demarcation is always distinct in adults. The whole ventral surface and the dorsal surfaces of the feet are of a dull white or silvery hue, irregularly darkened on the throat and belly by the slaty bases of the hairs, and sometimes washed with buff. A more or less bright spot of buff or orange is frequently present on the throat in well-developed specimens; sometimes this forms a complete collar, or is lengthened into a feeble median stripe; it is often quite minute or wholly absent. The ear is dull brown, with lighter or occasionally silvery edges. The tail is inconspicuously bicoloured, its upper surface being dark brown, whitish below.

Moult:—Specimens showing the moult are rare, and the change of coat is probably made in a gradual and inconspicuous manner (Barrett-Hamilton, *Proc. Zool. Soc.*, 1900, 399). Adams has seen only one case in which the line of demarcation was in moult; this, a young female (H. and B., 73 mm.; perforate) taken at Reigate in June, had the hinder and central part of the ventral surface in the first or grey pelage, while laterally and forwards the thick white adult pelage was developed. A

male (B.M., No. 98.2.1.18) from Holland, taken in September by Thomas, is moulting from the rufous to a duller coat, and has just a patch of the former colour on the rump, the rest of the body being dull (Barrett-Hamilton, *op. cit.*, 399).

Young:—The young are duller and more like House Mice in appearance than are the adults; their upper parts have usually a leaden tinge, their bellies are more slaty, and there is no well-marked line of demarcation.

Local variation:—From the evidence afforded by the skulls, discussed below, it is not at all unlikely that tangible local differences of colour exist among the British Field Mice; but a very carefully collected set of summer and winter specimens from several selected localities must be obtained before any attempt at defining such differences can succeed. It was noted that amongst British specimens summer skins from Oxfordshire and Leicestershire were the brightest and reddest; an old nursing female from Glamorganshire, taken in July, was, however, as brightly coloured as any of them. Field Mice from the London Parks are very dark and smoky, as are the birds and Lepidoptera, but in their case the change is doubtless a pathological one. The sub-species *Mus s. celticus*, Barrett-Hamilton (*op. cit.*, 401), was based upon some small dark-coloured specimens from Co. Kerry, Ireland, and similar specimens from this locality were described long ago by Jenyns (*Ann. and Mag. Nat. Hist.*, 1841, June, 268); the typical series, however, are all immature, and do not differ from young individuals of *A. s. sylvaticus*. In a long series taken in Skye by Mr P. D. Montague in March, and by Mr C. H. B. Grant in July (see note on p. 422 above), the backs are rather dark and the ventral surfaces frequently show traces of a median wash of yellow. Specimens from the Highlands also appear to average darker than those from southern England. These Scotch mice make an approach towards the small dark form inhabiting Bute, which, having distinctive skull characters in addition, is described below as a distinct sub-species.

The **skull** (Fig. 89) is lightly built, and of moderate size; its dorsal line is at first straight, rising from the nasal tips to the inter-orbital region, whence it is gently convex to the occiput, the highest point being in the mid-parietal region; its ventral line is nearly horizontal to behind the tooth-rows, and then slopes rapidly down to the level of the lower surfaces of the bullæ. The brain-case is very smooth, of oval or sub-circular form; the upper limits of the temporal fossæ are marked on its sides and shoulders by a very feeble ridge, which on each side is continued forwards into the smoothly squared edge of the hinder part of the inter-orbital region. The inter-parietal is short, but very wide; its lateral extremities are drawn out as pointed processes which approach the squamosals, and it is wholly posterior to the straight lambdoid

suture. The inter-orbital region is moderately constricted, about equal in width to the hinder part of the rostrum. The zygomatic arches are very slender, with delicate splint-like jugals; they are but slightly expanded, and drop rapidly from their maxillary roots to the alveolar level. The inferior zygomatic process of the maxillary is a massive plate, the vertical anterior border of which projects considerably in advance of the slender bridge-like upper process. The nasals are long and slender; they project noticeably in advance of the incisors, and are supported anteriorly on blade-like processes of the premaxillaries. The diastema is nearly twice as long as the tooth-row; the incisive foramina are long and reach back to a point opposite the front of m^1. The palate is flat; the maxillo-palatine suture does not reach further forwards than opposite the hinder part of m^1. The ecto-pterygoid plates are well developed; the pterygoid fossæ are shallow and slope backwards from the level of the palate to that of the basi-sphenoid; the inter-pterygoid space is long, narrow, and rectangular. The hamular processes curve outwards behind, and are in contact with the eustachian expansions of the small rounded bullæ; each bulla has a large meatus, the rim of which is slightly tubular. The basi-occipital is of moderate width, with a low median ridge and shallow lateral depressions; the paroccipital processes are very small; the body of the presphenoid is reduced in part to a thread of bone.

Adult skulls from different parts of the British Isles show, when carefully examined, slight but quite tangible differences of form and proportion, which indicate the tendency of the Field Mouse to develop races adjusted to the requirements of purely local conditions. Compared with skulls from central and southern England, those from Wales are slightly deeper and narrower, with smaller bullæ and slightly shorter post-molar and diastemal lengths; those from the lowlands of Scotland are relatively narrower throughout, with more depressed brain-cases and rather small bullæ; those from the Highlands are small, with slightly larger brain-cases, wider nasals, longer diastemata, and incisive foramina. Irish skulls agree more closely with those from England and Wales than with those from Scotland. Those from Man have slightly deeper brain-cases and longer palates. On Clare Island and Inishmore the skull seems to be considerably larger than usual, and this is the case also on Alderney and Scilly. Skulls from Jersey agree with the largest English specimens in size, but in several of their relative proportions they resemble those of the Scotch Highlands. For further details and summary of relative dimensions, see Hinton, *Ann. and Mag. Nat. Hist.*, July 1914, 118, and the table at p. 518[1] below.

[1] The measurements in this table (and those in that at p. 538) were made with great care and good instruments. The skulls measured were in all cases adult, the cheek-teeth being *at least* half worn.

The mandible is slender, with small but well-developed coronoid and long, rather slender, angular processes; the dental foramen is level with the alveoli; the incisor roots produce a small external projection at the base of each coronoid process.

Cheek-teeth are typical of the *sylvaticus* group, and have been described above under the genus (p. 504, Pl. XXVIII. Fig. 5.)

Exceptional variation:—Melanism appears to be very rare. Millais (*Mamm.*, 197) mentions one "perfectly black," shown by Borrer to Harting, but the specimen was not forthcoming; a "black and white" field mouse, which attracted notice by "producing a chirping noise," is recorded by R. P. Williams (*Proc. Dublin Nat. Hist. Soc.*) in *Nat. Hist. Review*, v., 1858, 188. A good many completely or partially albinic individuals have been recorded, *e.g.*, (1) one from Highwood, Middlesex (Cox, *Field*, 18th January 1873, 51); (2) a pink-eyed nursing female, Great Marlow (Cocks, *Zoologist*, 1884, 226); (3) pale buff, Broxton, Cheshire, in Grosvenor Museum, Chester (Newstead, *Chest. Soc. Nat. Sci. and Lit. Proc.*, iv., 249); (4) (Forrest, *Zoologist*, 1910, 307); (5) three cream-coloured in J. Whitaker's collection; (6) "young albino," Montgomeryshire (Forrest, *MS.*); (7) a buff female, black hairs entirely absent, from Brent Knoll, Somerset (No. 3.12.17.1 of British Museum collection, Percival); (8) male, silvery grey without reddish tints, alive with Laver (*lit.*, 22nd October 1905). Such cases cannot, however, be said to be common; Laver (*lit.*, 9th April 1904) said that he had only seen one, out of a thousand examined. Adams says:—"The only albinism I record is at the tip of the tail (twice)."

Geographical variation:—In addition to the typical form, four distinct sub-species are now recognised in Europe. These are:—(1) *A. s. butei*, Hinton, from the island of Bute, Scotland, described below; (2) *A. s. callipides*, Cabrera (*Bol. Real. Soc. Españ. Hist. Nat.*, Madrid, vii., 227, November 1907), a large dark-coloured form, in which the hind foot frequently measures 23 mm., while the condylo-basal length is 23·6 mm. or more, inhabiting the mountains of the Pyrenees-Asturias chain, and ranging southwards into Portugal; (3) *A. s. dichrurus*, Rafinesque (*Précis des Découvertes Somiologiques*, 1814, 13), which agrees with *callipides* in size, but differs from both it and true *sylvaticus* in its pallid and dull coloration, due to the suppression of the rufous and the predominance of the yellow and grey tints; this mouse was described from Sicily, and it inhabits the Mediterranean region from the Balkan Peninsula to central and southern Spain; (4) *A. s. creticus*, Miller (*Ann. and Mag. Nat. Hist.*, November 1910, 460), a mouse no larger than true *sylvaticus*, but of pale and more yellowish colour, which is known only from the island of Crete. A considerable number of sub-species have been described from Asia; of these the more conspicuous are:—*A. s. tauricus*, Barrett-Hamilton (*Proc. Zool. Soc.*, 1900,

412), from Asia Minor, a small form in which the total length of the skull is no more than 23 mm.; *A. s. witherbyi*, Thomas (*Ann. and Mag. Nat. Hist.*, December 1902, 490), described from the mountains (5200 feet) near Sheoul, Fars, southern Persia, a desert race with pale grey upper side, pure white belly, and small teeth; *A. s. arianus*, Blanford (*Journ. cit.*, 1881, 162), similar to the last in appearance, but with larger teeth; this mouse was described from Kohrud, between Ispahan and Teheran, Northern Persia, where it was found at a height of 7000 feet; Thomas (*Ann. and Mag. Nat. Hist.*, March 1909, 262) records it from the hills round Samarkand, Turkestan; *A. s. tscherga*, Kastchenko, is a small sub-species with a relatively short tail, inhabiting the Altai Mountains, Central Asia; *A. s. pentax*, Wroughton (*Journ. Bombay N.H. Soc.*, April 1908, 283), from the northern Punjab, is characterised by its short tail and narrow skull; lastly, *A. s. wardi*, Wroughton (*op. cit.*, 282), which occurs at a great elevation (9000-11,500 feet) in the mountains of Kashmir, a drab-coloured form, is worthy of mention. The North African forms are referred to two sub-species, *A. s. hayi* (Waterhouse) from Tangier, Morocco, and *A. s. algirus*, Pomel.

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
SPECIMENS FROM REIGATE, SURREY, CAUGHT AND MEASURED BY L. E. ADAMS.					
SEXUALLY IMMATURE OF BOTH SEXES:—					
1. 5th Sept. 1912, average of 6, 1 to 2 days old; quite naked and blind, ears under skin, umbilical scar	32	11	6	..	1·7
2. 28th April 1912, caught in the open; first pelage, eyes open	53	43	18	5	4
3. 15th Sept. 1912, average of 5; eyes open, suckling in nest	56	44	17	7	7
4. 26th Oct. 1912, male; first pelage. .	60	55	20	13	7
5. 24th Sept. 1900, female; first pelage .	61	67	20	..	..
6. 28th Sept. 1913, male; juvenal pelage below	65	67	19·5	12	7·5
7. 6th Nov. 1911, female; first pelage .	68	71	21	13	8·5
8. 14th Oct. 1913, female; juvenal pelage below	72	70	21	15	12
9. 7th June 1912, female; changing from grey to white below	73	67	21	14	11
10. 11th Aug. 1909, male; full pelage, but genitalia immature	73	76	20	..	..
11. 6th May 1913, female; perforate, but juvenal pelage	74	73	22	16·5	14·5
12. 22nd Oct. 1913, male; testis 3 mm., adult pelage	75	68	20	14	12
13. 17th Sept. 1913, male; testis 11 mm., juvenal pelage below, adult above .	78	76	22	13	12
14. 21st May 1913, male; juvenal pelage above, adult white below . . .	82	80	23	17	17
15. 22nd Oct. 1913, female; adult pelage, but imperforate	82	77	21	15	15
16. 25th Feb. 1913, female; imperforate, first pelage	83	90	22	15	17
17. 19th Feb. 1913, female; imperforate, first pelage	86	83	22	15	16

DIMENSIONS IN MILLIMETRES—*continued*:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
Sexually Mature Males:—					
1. 26th Aug. 1911	91	89	22	15·5	22·5
2. 1st Sept. .	90	90	22	16	24
3. 7th ,, .	89	92	22	15	19
4. 9th ,, .	87	93	22·5	16	18
5. 9th ,, .	84	94	23	16	18
6. 9th ,, .	83	89	22	15	14
7. 20th ,, .	81	76	21·5	15	15
8. 20th ,, .	83	88	22	15	15
9. 20th ,, .	89	100	22	16	26
10. 21st ,, .	83	90	23·5	16·5	17
11. 22nd ,, .	88	98	22·5	16·5	22·5
12. 23rd ,, .	84	83	22	16	17
13. 24th ,, .	89	91	22	15·5	19
14. 28th ,, .	90	97	23	16·5	22
15. 28th ,, .	87	94	23·5	15·5	20
16. 28th ,, .	86	91	21	14	16
17. 1st October .	88	94	23	15	23
18. 4th ,, .	92	89	22	16	23
19. 23rd ,, .	90	90	22	15	22
20. 25th ,, .	88	82	21	15	20
Average . .	87·6	87	22·2	15·5	19·6

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
Sexually Mature Females:—					
1. 25th Aug. 1911	87	78	23	15·5	21
2. 29th ,, .	90	90	20	15	21
3. 20th Sept. .	88	80	21	16·5	19[1]
4. 21st ,, .	93	88	22	16·5	24[2]
5. 22nd ,, .	94	88	21·5	17	21[3]
6. 26th ,, .	85	91	22	16	21
7. 27th ,, .	85	85	21	16	18[4]
8. 27th ,, .	90	87	22	15	27[5]
9. 28th ,, .	88	84	21	15	18·5[6]
10. 4th October .	90	87	22	16	19
11. 10th ,, .	85	82	21	15	22[7]
12. 23rd ,, .	85	82	22	15	22
13. 25th ,, .	87	82	21	14	18[8]
14. 27th ,, .	88	84	21	15	17[9]
15. 6th November	91	93	22	17	22[10]
16. 6th ,, .	88	88	22	16	21[11]
17. 8th ,, .	83	83	22	15	17
18. 1st May 1912	85	85	21	15	29[12]
19. 18th ,, .	89	90	22	16	23[13]
20. 23rd ,, .	83	81	22	16	17[14]
Average . .	87·7	85·4	21·6	15·6	20·9

[1] 4 minute embryos. [2] 3 minute embryos. [3] 5 minute embryos. [4] 3 embryos. [5] 2 embryos.
[6] 7 embryos. [7] 5 embryos. [8] 4 embryos. [9] 2 embryos. [10] Suckling.
[11] 4 small embryos. [12] Suckling; stomach and intestines crammed with food.
[13] Suckling. [14] Impregnated; embryos indistinguishable.

A. SYLVATICUS BUTEI, BUTE, COLLECTED BY R. W. SHEPPARD.

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).
Males:—				
9th March 1912 .	95	78	21	15·7
12th ,, .	90	80	22·7	15·5
13th ,, .	90	80	23	15
16th ,, .	90	75	22·5	15
17th ,, .	90	77	21·7	15
20th ,, .	100	86	22·5	15
20th ,, .	87	76	22	14
21st ,, .	95	85	22·5	15
23rd ,, .	95	75	22	12·5
Average of 9 .	91·3	79·1	22·2	14·7

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).
Females:—				
12th March 1912 .	80	78	23	14·5
13th ,, .	88	75	22	14·7
14th ,, .	90	75	22·7	13·5
16th ,, .	85	73	21	16
20th ,, .	90	90	22	15
20th ,, .	83	67	20·5	14·5
21st ,, .	80	80	21	14·5
22nd ,, .	80	73	22·3	16
Average of 8 .	84·5	76·4	21·8	14·8

Remarks:—The average measurements for adult *sylvaticus* given in the above table are rather small. This seems to be due in part to the fact that the specimens were taken chiefly in the late summer or autumn,

when many adolescent mice are to be found; mice collected in March or April would probably have given a greater average size for each sex. Six males, collected in East Aberdeenshire by C. S. Burnett between 11th and 17th April 1914, with skulls of the "Highland" type, averaged 94—92·2—21·6—16·1, the largest being 99—105—22—16. Aged English individuals probably attain a slightly greater size, although, no doubt, specimens in which the head and body exceeds 100 mm. are rare. The two largest (both males) caught at Reigate by Adams had the head and body 98, the tail 88 and 86 mm.[1] Two (male and female) of a series taken at Lowestoft, Suffolk, by Oldfield Thomas were measured as 100—94 and 93—22·5 and 21·2. Two males collected near Bridgend, Glamorganshire, measured 103—85—23, and 106—83—23. A male from Cashel, Tipperary, was measured by De Winton as 103—70 (damaged)—22·5—16.

Distinguishing characters:—Apart from the contrast between reddish upperside and white belly, the large foot is the most infallible point of distinction between any form of *Apodemus* and other British mice of somewhat similar size; the peculiarities of the skull and teeth, when available for examination, will always prevent any confusion with other genera. Immature Field Mice in the grey juvenal pelage may easily be confused with House Mice, especially when both are caught together out of doors; the slender feet and bicoloured tail afford perhaps the best outward means of distinguishing the young Field Mouse. The adult *A. sylvaticus* is distinguished from *A. flavicollis wintoni*, the only form with which it is likely to be confused on the British mainland, by its smaller size, duller coloration, and usually by the small size or absence of the pectoral spot.

(2) *A. sylvaticus butei* (Hinton).

1914. A. SYLVATICUS BUTEI, M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, July 1914, 123; described from Mountstuart, Bute, Scotland; type an old male, No. 15.5.29.33 of the British Museum collection.

1913. A. SYLVATICUS SYLVATICUS, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Proc. Zool. Soc.*, London, 1913, 835.

Distribution:—The island of Bute.

Description:—Size nearly as in *A. s. sylvaticus*, but with relatively much shorter tail and slightly shorter ears. General colour darker, the back and rump being rather heavily clouded with black; a faint trace of the pectoral spot is frequently present.

The **skull** is small, having in adults an average condylo-basal length of 22 mm. instead of 23 mm., as in true *sylvaticus*; its relative dimensions show, when compared with those of English skulls of the latter sub-

[1] In 95 males measured by Adams the head and body averages about 90 mm., in 59 females 89·2 mm.; he found plenty up to 97 or 98 mm.

CRANIAL DIMENSIONS OF *APODEMUS SYLVATICUS* AND *A. FLAVICOLLIS*:—

	APODEMUS SYLVATICUS.							*A. FLAVICOLLIS WINTONI.*
	sylvaticus, England.	Wales.	Ireland.	Scotland. 1. Lowlands.	Scotland. 2. Highlands.	Skye.	*butei,* Bute.	Hereford and Shropshire.
Number of Skulls measured :—	12	4	6	3	11	8	11	3
1. Condylo-basal length	22·0 to 23·6	22·2 to 23·6	22·5 to 23·7	23·2 to 23·5	22·0 to 23·4	21·1 to 23·3	20·4 to 23·2	25·9 to 26·2
Do. average	**23·0**	**22·97**	**23·08**	**23·33**	**22·6**	**22·46**	**21·94**	**26·06**
2. Occipito-nasal length	24·5 to 26·1	24·7 to 25·8	24·5 to 25·9	25·2 to 25·5	24·2 to 26·1	23·6 to 25·5	22·7 to 26·2	28·3 to 28·5
3. Zygomatic breadth	12·0 ,, 13·4	12·5 ,, 12·7	12·4 ,, 13·0	12·1 ,, 12·6	11·9 ,, 12·7	11·9 ,, 13·1	11·2 ,, 13	14·3 ,, 14·6
4. Inter-orbital breadth	3·8 ,, 4·4	3·9 ,, 4·2	4·0 ,, 4·2	3·8 ,, 3·9	3·8 ,, 4·2	3·8 ,, 4·2	3·8 ,, 4·3	4·3 ,, 4·5
5. Cranial breadth	11·1 ,, 12·2	11·2 ,, 11·7	11·1 ,, 11·8	11·0 ,, 11·3	11·1 ,, 12·0	10·7 ,, 11·6	10·5 ,, 11·8	12·2 ,, 13
6. Cranial depth (middle)	7·2 ,, 8·3	7·9 ,, 8·2	7·5 ,, 8·0	7·4 ,, 7·8	7·5 ,, 8·5	7·7 ,, 8·5	7·3 ,, 8·1	8·5 ,, 8·7
7. Condyle to m^3	10·3 ,, 11·1	10·4 ,, 11·1	10·5 ,, 11·0	10·7 ,, 11·0	10·0 ,, 11·0	9·6 ,, 11·1	9·4 ,, 10·8	12·4 ,, 12·5
8. Condyle to front of bulla . . .	5·9 ,, 6·7	5·9 ,, 6·3	6·1 ,, 6·4	6·2 ,, 6·4	6·0 ,, 6·6	5·4 ,, 6·3	5·7 ,, 6·4	7·3 ,, 7·8
9. Nasal length	8·8 ,, 9·7	9·0 ,, 9·4	8·8 ,, 9·7	9·2 (2)	8·5 ,, 9·4	8·5 ,, 9·5	8·1 ,, 10·2	9·9 ,, 10·6
10. Nasal width	2·6 ,, 3·0	2·6 ,, 2·7	2·6 ,, 2·8	2·5 ,, 2·6	2·6 ,, 2·9	2·5 ,, 2·6	2·3 ,, 2·8	3·0 ,, 3·3
11. Palatal length	11·8 ,, 12·8	12·0 ,, 12·9	12·0 ,, 12·9	12·5 ,, 12·7	12·0 ,, 12·8	11·4 ,, 12·7	11·1 ,, 12·6	13·7 ,, 14
12. Diastema	6·3 ,, 6·9	6·1 ,, 6·9	6·2 ,, 6·7	6·5 ,, 6·8	6·2 ,, 6·8	6·0 ,, 6·6	5·9 ,, 6·6	7·3 ,, 7·4
13. Incisive foramina (length) . . .	5·0 ,, 5·6	5·1 ,, 5·6	5·1 ,, 5·6	5·5 ,, 5·8	5·0 ,, 5·8	4·8 ,, 5·6	4·8 ,, 5·5	5·0 ,, 5·5
14. Incisive foramina (width) . . .	1·5 ,, 1·8	1·7 ,, 1·9	1·5 ,, 1·8	1·5 ,, 1·7	1·5 ,, 1·9	1·5 ,, 2	1·5 ,, 1·9	1·8 ,, 1·9
15. Rostral breadth	4·2 ,, 5·0	4·3 ,, 4·8	4·2 ,, 4·8	4·3 ,, 4·6	4·3 ,, 4·8	4·2 ,, 4·4	4·0 ,, 4·5	5·3 ,, 5·5
16. Masseteric plate, least width . .	2·1 ,, 2·6	2·2 ,, 2·6	2·3 ,, 2·8	2·2 ,, 2·5	2·1 ,, 2·5	2·1 ,, 2·4	2·1 ,, 2·5	2·6 ,, 2·8
17. Maxillary cheek-teeth	3·3 ,, 3·9	3·4 ,, 3·7	3·5 ,, 3·8	3·5 ,, 3·8	3·3 ,, 3·7	3·5 ,, 3·8	3·3 ,, 3·7	3·7 ,, 4
Mandible length	13·8 ,, 14·6	13·7 ,, 14·4	13·8 ,, 15·3	14·1 ,, 14·5	14·0 ,, 14·7	13·2 ,, 14·5	12·9 ,, 14·2	15·9 ,, 16·4
Mandibular cheek-teeth	3·4 ,, 3·8	3·4 ,, 3·6	3·5 ,, 3·7	3·5 ,, 3·7	3·4 ,, 3·7	3·5 ,, 3·8	3·3 ,, 3·7	3·8 ,, 3·9

REDUCTIONS: 1. = 100	100	100	100	100	100	100	100	100
2. =	108 to 111·5	108 to 112	106·5 to 111	107 to 110	108 to 112	109·5 to 112	109 to 113	109 (3)
Average	**110·08**	**109·5**	**108·66**	**108·5**	**110**	**110·08**	**110·85**	**109**
3. =	52·2 to 57·7	53·5 to 56·3	54·3 to 56·8	52·1 to 54	52·2 to 57·2	55·2 to 57·5	54·9 to 57·7	54·8 to 55·7
Average	**55·75**	**54·82**	**55·13**	**52·8**	**54·59**	**56·32**	**56·32**	**55·23**
4. =	16·6 to 18·8	16·5 to 18	16·9 to 18·7	16·3 to 16·8	16·8 to 18·9	16·7 to 19·2	17·2 to 19·6	16·5 to 17·2
Average	**17·73**	**17·5**	**17·57**	**16·56**	**17·6**	**18·03**	**18·44**	**16·9**
5. =	48·4 to 51·7	47·5 to 50·4	47·8 to 50·7	47·2 to 48·1	49·1 to 54	49·7 to 52·5	49·1 to 53·7	46·7 to 49·6
Average	**49·68**	**49·25**	**49·35**	**47·7**	**50 63**	**50·65**	**51·9**	**47·93**
6. =	31·7 to 35·5	34·3 to 37	31·7 to 34·3	31·8 to 33·6	34·1 to 37·8	33·9 to 37	33·8 to 37·5	32·8 to 33·3
Average	**34·02**	**35·17**	**33·36**	**32·56**	**35·56**	**36·01**	**35·76**	**33·1**
7. =	46·2 to 47·8	46·4 to 47·1	46·0 to 47·4	45·9 to 46·8	45·5 to 47·4	45·5 to 47·8	45·8 to 47·7	47·6 to 47·9
Average	**47·25**	**46·77**	**46·86**	**46·26**	**46·43**	**46·56**	**46·56**	**47·76**
8. =	26·3 to 29·4	25·9 to 27·6	26·6 to 27·6	26·6 to 27·2	27·2 to 28·2	25·6 to 28·3	26·7 to 28·5	28·2 to 29·9
Average	**27·45**	**26·77**	**26·93**	**26·96**	**27·61**	**27·02**	**27·7**	**28·76**
9. =	38·0 to 42·3	39·8 to 40·6	39·1 to 41·6	39·1 to 39·6	37·9 to 41·8	38·7 to 40·9	38·0 to 44	37·9 to 40·9
Average	**39·89**	**40·15**	**40·06**	**39·35**	**40·1**	**39·62**	**40·72**	**39·63**
10. =	11·2 to 12·7	11·1 to 11·8	11·2 to 12·4	10·7 to 11	11·2 to 13·2	10·7 to 11·9	10·7 to 12·8	11·6 to 12·65
Average	**11·89**	**11·52**	**11·92**	**10·83**	**12·18**	**11·35**	**12·03**	**12·01**
11. =	53·1 to 55·2	53·2 to 54·7	53·1 to 54·4	53·9 to 54·5	52·5 to 56·2	51·8 to 55·2	53·3 to 55	52·5 to 53·6
Average	**53·94**	**53·82**	**53·62**	**54·13**	**54·46**	**53·7**	**54·3**	**53·13**
12. =	27·5 to 29·8	27·5 to 29·2	27·6 to 28·8	28·0 to 28·9	27·6 to 29·6	27·4 to 28·9	27·4 to 29·3	27·8 to 28·4
Average	**28·51**	**28·05**	**28·3**	**28·53**	**28·9**	**28·11**	**28·35**	**28·13**
13. =	21·9 to 24·4	22·1 to 24	22·7 to 24·4	23·6 to 25	22·3 to 25·2	22·7 to 25·2	23·3 to 24·6	19·3 to 21
Average	**23·25**	**23·07**	**23·55**	**24·13**	**23·72**	**24·05**	**23·8**	**20·2**
14. =	6·6 to 7·9	7·2 to 8·15	6·45 to 8	6·4 to 7·3	6·85 to 8·35	7·1 to 8·6	6·8 to 8·35	6·85 to 7·3
Average	**7·34**	**77·2**	**7**	**6·86**	**7·78**	**7·78**	**8·04**	**7·03**
15. =	18·3 to 21·4	19·1 to 21	18·0 to 20·9	18·5 to 19·7	19·4 to 21·6	18·4 to 19·9	18·2 to 20·8	20·2 to 21·1
Average	**20·28**	**19·8**	**19·65**	**19·13**	**20·26**	**19·11**	**19·43**	**20·7**
16. =	9·0 to 11·4	9·9 to 11·4	9·9 to 11·8	9·35 to 10·8	9·55 to 11·3	9·6 to 10·9	9·65 to 11·2	9·9 to 10·7
Average	**10·25**	**10·75**	**10·74**	**10**	**10·31**	**10·07**	**10·52**	**10·33**
17. =	14·85 to 17	14·6 to 16·2	15·1 to 16·5	15·0 to 16·2	15·0 to 16·7	15·7 to 17·6	15·1 to 17·2	14·3 to 15·3
Average	**15·64**	**15·57**	**15·83**	**15·56**	**15·77**	**16·33**	**16·25**	**14·95**

species, distinctly greater zygomatic, inter-orbital, and cranial breadths, a deeper brain-case, shorter post-molar region (the bullæ being, however, enlarged rather than diminished), longer and rather wider nasals, greater palatal length, slightly longer and much wider incisive foramina, narrower rostrum, and longer molars.

For external and cranial dimensions, see tables at pp. 516 and 518 respectively.

Status:—*A. s. butei* is quite clearly differentiated from the English *A. s. sylvaticus*, and may be regarded as an insular development of either the same stock, or else of an older stock of mice of the *sylvaticus* type. Its exact significance cannot be appreciated until the relationship of the Highland Field Mice to those of England and the lowlands has been determined. The Field Mice of Skye and the Highlands approach *A. s. butei* more or less closely in some respects, and thus appear to occupy an intermediate position between it and the English *sylvaticus*. Among other Hebridean Field Mice the Bute form is readily distinguishable by its small size, dark coloration, and skull characters.

The habits of the Field Mouse are not far removed from being typical of those of mice generally. It is a hardy, active, non-hibernating animal of primarily vegetarian, but, when necessity arises, omnivorous diet, a fine jumper, a good climber, a capable digger, and a fair swimmer. It may, therefore, be found in any situation frequented by mice, as it is not tied down to the habitats of those which have become specialised in any particular direction. Thus it cannot compete with the House Mouse in the dwellings of mankind, and does not usually accompany it or the Harvest Mouse to the stackyards. Its activity and preference for a diet of berries and grain rather than of grass, raises it above the monotony of a Grass Mouse's existence, and keeps it in woods and the hedgerows of cultivated lands; it sometimes swarms in cornfields towards harvest-time. But it is found also in more open and barren districts, and is often numerous and well grown on desolate islands or rough mountains. In Clare Island, Co. Mayo, Ireland, it inhabits the walls of loose stones right up to the summits of the hills, and in the opposite direction, it may be found on the sea beach,[1] generally in the marram-grass,[2] the

[1] G. T. Rope, *Zoologist*, 1874, 3865.

[2] G. T. Rope (*Zoologist*, 1887, 206) thus encountered it between Dunwich and Sizewell, Suffolk, on a beach cut off from cultivated land by wide marshes.

seeds of which and of other plants it probably eats, with the addition of the varied dainties cast up by the waves. Its adaptability is so wide that it thrives equally well in the flower-beds of Regent's Park, London, and on the lonely hills of Sutherland.[1] As an instance of its powers of surviving in unusual situations—Mr J. E. Harting once caught one which landed at Dobbin Island, Pagham Harbour, Sussex,[2] Mr G. T. Rope has observed one swim out leisurely into the centre of a pond,[3] a correspondent of Mr H. E. Forrest (*N. Wales*, 1907, 50) watched one swim a considerable distance across flood water at Llanderfel, and Mr Millais (p. 195), suggests that it is capable of swimming 200 yards without fatigue. It is, of course, a much wider wanderer than any of the "Voles," and predominantly, if not entirely nocturnal,[4] which is no doubt a cause of its prominent round eyes, recalling those of the Dormouse. Yet, like the Common Shrew and Bank Mouse, it may be trapped by daylight, so that it is unsafe to lay down an absolute rule of conduct for it. Individuals of nocturnal animals found out by day are usually either feeble, sick, or senile.

Where it abounds, it may be found at night, if searched for with a lantern, bounding along in a peculiar zigzag and erratic manner,[5] remotely resembling the movements of a kangaroo or gerboa, and at all times, even when it walks, its long hind feet give it a characteristic "action" in moving about, which is probably its most peculiar feature; and Mr Douglas English has known one to leap down 15 feet, and proceed unhurt, thus showing the elasticity of its limbs. The tracks of the Field Mouse (Fig. 85) are characterised by the length of the median tail mark; Adams has observed them in snow extending for a distance of 100 yards—clear proof that these mice roam comparatively far from their homes. It sits bolt upright, using the tail for support.

Its large ears appear capable of detecting the slightest sound; they twitch convulsively at a chirp or whistle so faint

[1] Millais (189).

[2] Specimen in British Museum of Natural History; see also Harting, *Zoologist*, 1891, 185.

[3] *Zoologist*, 1891, 185.

[4] Lataste; Rope, *Zoologist*, 1887, 201.

[5] Rope, *Zoologist*, 1887, 206. I made similar observations respecting the nocturnal *Muridæ* in South Africa (Barrett-Hamilton).

as to be barely audible to human ears.[1] The sense of smell is probably acute also, and perhaps the principal guide in the search for food.

In disposition it is gentle and inoffensive, slow to retaliate, so that it rarely bites unless roughly handled. Extremely timid, it cannot, perhaps on account of poor sight, be called shy, for it may sometimes be observed from a close distance, or caught with the hand,[2] and no animal is more easily trapped. The Field Mouse lacks the objectionable odour of the House Mouse, so that, like the Dormouse, it ought to prove a suitable pet; but, although extremely beautiful, it is not as intelligent as the House Mouse, and, while easily fed, frequently breeding, and sometimes exceptionally friendly, it does not always become so tame as to repay the trouble expended on it. Some, however, have found it very attractive, and the late Dr W. E. Leach[3] is said to have allowed several to run about freely on his breakfast table. It sometimes enters houses, perhaps by climbing the creepers, but this habit is more characteristic of the Yellow-necked Field Mouse.[4]

FIG. 85.—SPOOR OF FIELD MOUSE IN SNOW.
(From a sketch by L. E. Adams.)
Hind feet (dark) on top of prints of fore feet (lighter).

[1] G. T. Rope, *Zoologist*, 1887, 203.

[2] Eliza Brightwen, *More About Wild Nature*, 1892, 58; and L. E. Adams in Millais, 189.

[3] Bell, ed. ii., 294; see also, Eliza Brightwen, *op. cit.*, 120.

[4] See William Thompson, *Nat. Hist. Ireland*, iv., 15, for Ireland (Belfast); W. Evans for Scotland (Edinburgh district); G. Rope, *Zoologist*, 1887, 206 (visits dairies for milk); Millais, 189; Coward and Oldham; Jenyns, *Observations in Natural History*, 1846, 74.

It seems to be at least partially gregarious. Mr G. Bolam states that it appears to live in pairs, and the young associate with the parents until a considerable age (*Bradford Sci. Journ.*, Jan. 1912, 213). Dr Henry Laver finds that the work of storing provisions is shared by a company, and that fourteen or fifteen may sometimes be dug out of the burrow. Consequently in captivity a large number may be kept together, the males, females, and young sleeping together in perfect amity, and the latter being even fed indiscriminately[1] by the mothers,[2] as found by Mr R. M. Barrington. These observations indicate that the wild male is not dangerous to his family, but not necessarily that he resides with them. The fact that the dams would suckle the young of the colony promiscuously might result from the confusion[3] resulting from a mixed *ménage*, in which identification of any particular offspring would be impossible to keep up. The observations show, however, that the mice are extremely sociable and good tempered, friendly to strangers of their own species, and that their system is quite opposed to that of the exclusive Water Rat.

Its dietary is of the usual wide murine type, ranging from roots, bulbs, nuts, and berries to members of its own species,[4] but avoiding the grass-stalks beloved of Grass Mice. It is a great plague in cornfields and gardens, especially to early sown peas.

According to Mr Barrington's[5] observations these mice seldom feed on blades of grass, but more often on the roots; they eat clover and dandelion leaves, while the unexpanded dandelion flower seemed to be esteemed a great delicacy; also milk, oats, wheat, barley, chestnuts, beech nuts, walnuts, arbutus berries, gooseberries, apples, grapes, and every variety of fruit; almonds were not much liked; the captives liked to tear a lot of grass to pieces. Mr Adams describes his captives as peeling but not eating horse-chestnuts, refusing apples and

[1] Observations of this sort made on captive animals under artificial conditions must be applied with great care to wild individuals. [2] *Zoologist*, 1882, 121-3.

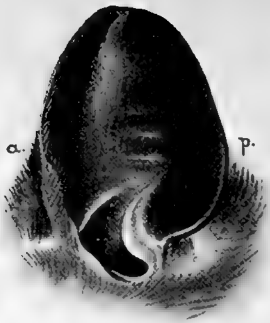
[3] Cows are quite sociable and gregarious animals, and, if allowed to rear their calves, are attached only to their own young. But if a number of cows and calves be confined in a yard for a very few hours they soon lose the power of distinguishing their own young, and promiscuous suckling results.

[4] In eating a mouse it begins with the brain, and then eats a large hole in the back, whereas shrews begin at the upper ribs, and then eat their way to the brain (L. E. Adams, *MS.*). [5] *Loc. cit.*

not touching almonds or grass; crocus bulbs were eaten readily, but acorns were, with the exception of carrion (their fellows, Bank Mice and Shrews), the favourite food; "my captives did not care for haws, though they preferred them to hips; this was doubtless because they had the choice of so many dainties." Lataste's captives fed on grains, bread, salad, carrots (little), potatoes (little), nuts and almonds especially; sloes appear in the list given by Oldham and Coward[1]; when wild,[2] they eat the seeds of butcher's broom and are fond of carrots. Bell (*ipse*, ed. ii., 294) mentions stores of acorns, nuts, corn, various seeds and roots; Mr Steele Elliott,[3] in addition to some of these, found haws, holly berries, and fungi, e.g., *Boletus badius* and *Paxillus involutus*, in winter stores; cherry stones in store were found by Mr St John[4]; hips and blackberry seeds are mentioned by Mr C. Oldham,[5] slow-worms by Mr W. H. P. Saunders,[6] eggs by Mr E. T. Danberry[7]; strawberries in heaps were observed by Barrett-Hamilton—"the habit of heaping its food being halfway towards storing." It has been known, "in common with others of the family, to eat considerable quantities of putty without apparently suffering any ill effects.[8]" A very extensive literature relating to their destructiveness may be found in the periodicals devoted to gardening. About 300 were trapped in a fortnight at a crocus bed by Heatley Noble (Millais, 190). These mice attack lily and hyacinth bulbs as well; on the other hand, their attacks on the latter are said to have indicated to Dutch growers a method of increasing the bulbs by splitting (Millais, 190). Service states[9] it to be very destructive to indoor fruit, as peaches, nectarines, tomatoes (ripe seeds).

Colonel Davies Cooke (in Forrest, North Wales, 50) describes it as entering and robbing beehives at Mold, and William Thompson (iv., 15) mentions two nests found in a beehive at Fort William, near Belfast, the mice having entered by the same aperture as the bees; numbers of the mice were caught

[1] *Op. cit.*
[2] G. Rope, *op. cit.*, 204; and Millais.
[3] *Journ. Birm. Nat. Sci. and Phil. Soc.*, 1896-9.
[4] *Nat. Hist. and Sport in Moray*, 234.
[5] *Zoologist*, 1900, 421.
[6] *Field*, 27th April and 4th May 1907.
[7] *Nature Notes*, 1899 (1900, Z. 157).
[8] Aflalo, 75.
[9] *Ann. Scott. Nat. Hist.*, 1896, 205.



(1)

(2) (2*a*) (3) (3*a*)

THE FIELD MOUSE (*Apodemus sylvaticus*).

(1) LEFT EAR; (2 and 2*a*) LEFT HAND; (3 and 3*a*) LEFT FOOT.
(Three times life size.)

in traps placed around the hives; and in winter the mice often broke into the hive and ate the honeycomb.[1] The connection between mice, humble bees, and clover as commented upon by Charles Darwin, is noted above under Grass Mouse at p. 452.

When climbing the hedgerows, which it does to the very tips of the branches, in search of berries, it frequently uses a bird's nest[2] as a dining platform, as perhaps first described by Mary Howitt,[3] in 1834, by Mr Charles Oldham,[4] in 1899, and by H. E. Forrest[5] in 1907. Sometimes what was meant for a temporary occupation becomes permanent, for Mr Millais (p. 192) found a deserted Blackbird's nest roofed over with moss; Mr Harting[6] found another case in which a Missel-thrush's nest, twelve feet up an oak, was roofed with grass and leaves; and a third instance was met with in the foundation of a Rook's nest in an elm of considerable elevation (Millais, 193). It is probable that on expeditions like this it sometimes yields to the temptation to devour young birds or eggs, whence these are included in its dietary by J. H. Blasius and Victor Fatio; Mr G. G. Cummings, however, accuses it of frequently sucking eggs, especially those of finches, and Mr G. H. Caton Haigh has known it to eat the heads off a nestful of young thrushes.[7] Mr Oldham found that the mice do not usually eat the soft parts of berries, but extract the seeds, as in the case of hips, through a hole nibbled in the side; they then chisel off one end of a seed and extract the kernel. The empty seed-case and the pulp are dropped on the nest until they may form a heap representing the contents of a quart measure.[8] It seems that the convenience of a bird's

[1] On the other hand, Barry (ed. ii., 1808) states that in Orkney the Field Mice are sometimes deprived of their burrows by the field bees.

[2] Those of Thrush, Blackbird, Hedge-sparrow, Greenfinch (7 feet from the ground), or even the fragile nest of the Whitethroat have been noted (Oldham). C. E. Wright has also seen this (MS. per L. E. Adams). The Bank Mouse makes a similar use of deserted nests (see p. 414 above).

[3] "In the Hedge-sparrow's nest he sits,
When its summer brood is fled,
And picks the berries from the bough
Of the hawthorn overhead."

Quoted by T. A. Coward, *Zoologist*, 1901, 221, from *Sketches of Natural History*, 1834, a volume of poems for children.

[4] *Zoologist*, 1899, 27. [5] *Op. cit.*, 50. [6] *Vermin of the Farm*, 1892, 14.

[7] In Mr H. E. Forrest's *North Wales*, 50. L. C. Creaghe-Haward (*Field*, 20th March, 1909, 510) suggests that a Field Mouse killed a Hedge-sparrow, but the evidence is not absolutely conclusive. [8] Mr Adams has made very similar observations.

nest is so much appreciated that acorns are carried up to them from the ground.

According to Blasius, it will bark young trees when in want, a circumstance noted also by Mr Rope[1] and Mr Abbey.

A remarkable winter habit of entering disused tunnels at Alderley Edge, Cheshire, to more than 150 yards from the entrance, was related by Mr Oldham,[2] the object, as shown by the contents of their stomachs, having been to feed on hibernating gnats, flies, and moths. The burrows in the tunnels themselves and the food seemed to indicate that they actually lived in the recesses for the time being, and became entirely insectivorous, and were not merely on a visit. In a case recorded by Mr Edwin Birchall[3] the wings of hundreds of individuals of twenty species of moths were found in a small cave by the river Wharfe, near Ilkley, Yorkshire; the circumstances pointed to the work of Field Mice, and on a trap being set, one was caught, the mice having apparently carried their prey into the cave from the adjoining woods. S. Clogg, however, referred the killing of the moths to a spider whose web was observed in the cave (*Zoologist*, 1866, 105, 350, 458; 1869, 1719; 1871, 2763); while Edward Newman (*ibid.*, 1866, 386), Henry Doubleday (*ibid.*, 1866, 387), and W. F. Howlett (*Journ. cit.*, 1871, 2802) attributed it to bats.

Quite unlike the House and Harvest Mice, the Field Mouse is rarely found in stacks of corn, and enters dwelling-houses very exceptionally, wherein it appears to differ from the Yellow-necked Mouse, which seems quite fond of houses.[4] An exceptional instance was sent us by Mr C. H. Alston, in whose house, at Letterawe, Loch Awe, Argyll, House Mice are fortunately unknown. Their place is taken by Field Mice, which seem to be now permanently in occupation. Unlike the House Mouse, they rarely gnaw a hole for themselves, but enter the house by burrowing through crevices in the stones in the foundations, and then creep up through small cracks in the floors, and thus get inside the partitions.

Its destructiveness is increased by its provident habit of

[1] *Op. cit.*, 204. [2] *Zoologist*, 1900, 421. [3] *Ibid.*, 1866, 8, 284.

[4] Mr Adams informs us that he has caught these mice frequently in cellars and outhouses; on one occasion he found some in a stack.

amassing[1] stores of provisions in a separate chamber of its burrow near its dwelling apartment or altogether apart, in which work it is very diligent. Mr R. M. Barrington[2] has observed that captives covered up single grains of wheat with the nose, like a dog, sometimes using the hind legs to scrape together a heap of material over it. Unlike dogs, they hid many things in the same place.

It certainly does not hibernate, for it may be trapped freely at the coldest part of the year. Charles St John[3] thought that on the approach of cold winds or rain they shut themselves up in their underground habitations, closing the apertures carefully, but corroborative evidence of this habit is desirable.

The Field Mouse is extremely prolific, and the female produces several litters in a long polyœstrous sexual season, which probably lasts the greater part of the year.

Mr Barrington[4] found that young captured on 1st October first made a nest of grass when about thirty-six days old. Of two females which, with a single male, survived to reach maturity, the produce was as follows, young being first born when the dams were about five and a half months old :—

Female A.—7th or 8th March,	3	young,	...	days' interval
31st March,	3	"	24	"
24th April,	3	"	24	"
17th May,	4	"	23	"
12th June,	4	"	26	"
9th July,	4	"	27	"

(In the case of the last two litters identification was not absolutely certain, one female having escaped.)

Female B.—19th March,	5	young,	...	days' interval
18th April,	5	"	29	"
11th May,	5	"	23	"

---

[1] A well-known habit :—

"Saepe exiguus mus
Sub terris posuitque domos atque horrea fecit."

Vergil, *Georg.*, i., 181 ; but why the rooting of pigs has been by writer after writer, at least from Pennant (1768) to Johnston (1903), supposed to be "chiefly owing to their search after the concealed hoards of the Field Mice," is difficult to understand.

[2] *Op. cit.*, 123.

[3] C. St John., *Nat. Hist. and Sport in Moray*, 1882, 234.

[4] *Op. cit.*

Until the young were three weeks old, the mother frequently carried them back to the nesting-box, usually lifting them by the side of the belly, midway between the fore and hind legs, the mother's erect head raising them completely above the ground. The dam soon discovered that her load must be changed at the narrow entrance to the nesting-box, and so dropping the young ones outside, she entered, and turning round dragged each baby in head foremost. Occasionally the parents attempted to drag older children into the nest.

Mr Barrington's remarks are confirmed by Dr Henry Laver,[1] who observed copulation, and found that the periods of gestation and œstrus seem to be respectively twenty-four to twenty-five and six days, copulation taking place a few hours after the birth of a litter, and six days after a previous ineffective pairing.

It must be noted that Mr Barrington's observations are in one or two respects abnormal. The original mice having been taken in the autumn, did not produce young until the following spring, when five and a half months old. Had they been the young of early spring litters, they might have been expected to breed when younger.

A female in the possession of Monsieur Fernand Lataste, being deprived of her young, imposed upon herself the task of rearing a strange baby, and Mr F. H. Parrott informed Mr Cocks that one he had reared a litter of Grass Mice.

As a result of his examination of thirty-four litters, Mr Adams thinks that the average number of young per litter is about five; he has seen one litter of nine young, three of seven, five of six, thirteen of five, nine of four, two of three, and one of two. Mr Adams has found young in every month of the year excepting January, and, very curiously, June and July.

The breeding habits probably resemble those of the House Mouse[2]; the young cling to the mother's teats just like other mice,[3] and it is extraordinary to what a pace she attains with

[1] *Field*, 19th August 1905, 378; and *in lit.*

[2] Lataste.

[3] Gilbert White, Letter lii. to Daines Barrington, 26th March 1773; R. M. Barrington, *op. cit.*; J. J. Briggs, *Zoologist*, 1856, 5311 (? species doubtful); Victor Fatio witnessed a female ploughed out of the ground with the young attached to her hair and tail (p. 213). The famous incident which made Burns write of a "wee sleekit, cowrin', tim'rous beastie" may be recalled. See also Rope, *Zoologist*, 1873,

a family of young, each probably a third of her own size, attached to her.

Some authorities, *e.g.* Bonhote, speak of a domed nursery built above the ground; and Mr Cocks has not infrequently found such during haymaking. In the autumn, according to Mr Adams, breeding-nests may be commonly found under roadside heaps of hedge-cuttings. Usually the nest is placed below ground in the characteristic burrow (Figs. 86, 87). The burrows are excavated in cornfields during the summer, and the mice often remain in them in the stubbles until the plough turns them out in the autumn.[1] Sometimes the burrows appear to be only of a temporary nature, a short steep tunnel, perhaps only two or three inches long, leading to a simple enlargement containing the usual murine globular nest of dried grass. The more permanent burrows may be 3 feet deep, and in them the mice commonly lay up stores of acorns, and stay through the winter (L. E. Adams).

Its voice in anger is described as somewhat high-pitched, but it makes other sounds of a quiet, chuckling nature.[2]

Although its annual fluctuations do not appear to be so violent as those of voles, it is said to have taken part in the mouse plagues which devastated the Forest of Dean in 1813-14 (see above at p. 451). As stated on p. 418 above, Mr Cocks observed great swarms of this species and of the Bank Mouse, at Poynetts, Buckinghamshire, in 1900. Macpherson mentions one which lived upwards of two years in captivity.

All predaceous creatures eat Field Mice when they have an opportunity, and in some localities they are the favourite food of owls, as shown by their pellets. Mr Aubyn Trevor-Battye was informed[3] that in the dry summer of 1893 the Black-headed Gulls[4] breeding on Scoulton Mere often brought "mice" to their young, but these were more likely to have been the diurnal Grass Mice than the nocturnal Field Mice.

3610. Adams once saw a female escape from the bolt-hole of her nest with three or four young hanging on; these dropped off as the dam leapt away, the last one at about 5 yards from the burrow.

[1] Adams once found "a breeding-nest underground on a Yorkshire moor, just like those in cornfields."

[2] Millais, 195. [3] Lydekker, 187. [4] *Larus ridibundus*, Linn.

No small mammal except the Common Shrew is more

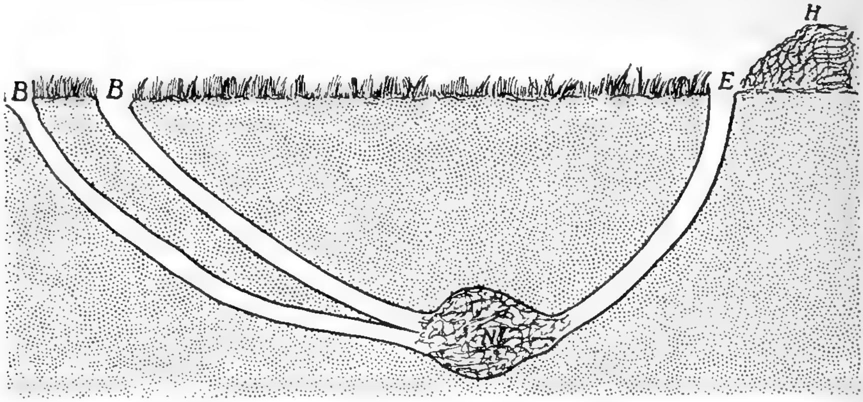


FIG. 86.—SECTION OF BURROW OF FIELD MOUSE (diagrammatic). *H*, heap of excavated earth, all at one entrance; *B*, *B*, bolt-holes; *N*, nest. (From a sketch by L. E. Adams.)

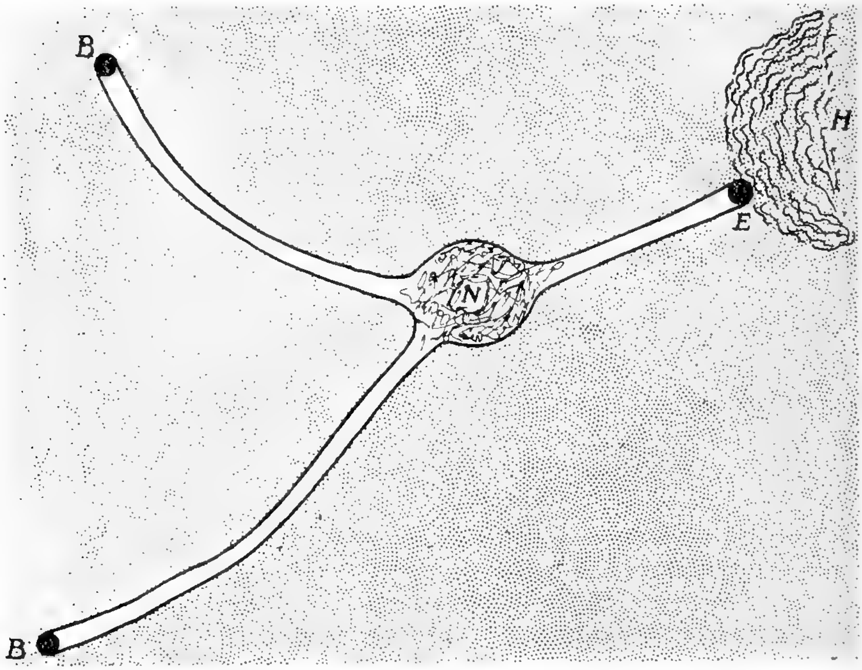


FIG. 87.—PLAN OF THE BURROW OF A FIELD MOUSE SHOWN IN SECTION IN FIG. 86. (From a sketch by L. E. Adams.)

easily trapped. It will take any edible bait, vegetable or animal, and no concealment is needed for the trap.

THE HEBRIDEAN FIELD MOUSE.

APODEMUS HEBRIDENSIS, de Winton.

1895. MUS HEBRIDENSIS, W. E. de Winton, *Zoologist*, October 1895, 369-371; described from Uig, Island of Lewis, Outer Hebrides, type specimen, No. 95.10.25.1 of British Museum collection; (*Apodemus*) Miller, *Catalogue*, 1912, 824.

1895. MUS SYLVATICUS HEBRIDENSIS, W. E. de Winton, *Zoologist*, November 1895, 426 (designates type specimen); Barrett-Hamilton, *Proc. Zool. Soc.*, London, 1900, 403; Johnston, Millais, Trouessart.

1913. APODEMUS SYLVATICUS SYLVATICUS, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Proc. Zool. Soc.*, London, 1913, 835 (in part).

History:—De Winton seems to have been the first to record the presence of field mice in the Outer Hebrides, where he trapped a number of specimens in Lewis in the summer of 1894 (*Ann. Scott. Nat. Hist.*, 1895, 53). In the following October (*loc. cit. supra*) he published a description of his *Mus hebridensis*, based on these specimens and others taken by Pinney in Barra. Later in the year Steele Elliott claimed priority for the discovery, but it appears that his remarks refer to the St Kilda Field Mouse, a different form, as, indeed, was suggested by de Winton. In the first paper on the mammals from the Inner Hebrides (see footnote to p. 422 above) we referred the field mice of Great Cumbrae, Arran, Gigha, Islay, Jura, Mull, and Tiree to *A. sylvaticus*. As the result of a detailed investigation of the cranial characters the field mice of the islands named, together with those of Rum and Eigg, have now to be regarded as local races or sub-species of *hebridensis*. Four of these forms have received names and are described below; it is highly probable that with further material several of the other insular races will have to be given sub-specific rank.

Description:—Size usually larger than in typical *sylvaticus*, and of stouter build; the feet longer; the tail and ears relatively shorter. The **coloration** varies in the different sub-species; sometimes the backs are dark, as in *A. h. hebridensis*, *maclean*, and *fiolagan*, sometimes rufous, with few black hairs, as in *cumbræ;* the underparts sometimes have a large pectoral spot, and are more or less generally suffused with buff or yellow, as in *h. hebridensis;* or the pectoral spot may be quite small or absent, and the whole ventral surface nearly clear silver, as in *maclean;* the line of demarcation may be irregular or straight, clearly or faintly defined, the degree to which it is evident being dependent upon the colour of the flanks as well as upon that of the ventral surface.

The **cheek-teeth** agree in form with those of *sylvaticus*. The **skull** is usually (but not in *cumbræ*) larger than in *sylvaticus;* in *hamiltoni* it approaches that of *flavicollis* in size. In general appearance it is like

that of *sylvaticus*, having the brain-case smoothly rounded; in *hamiltoni*, however, the fore part of the brain-case is angular and distinctly ridged. In all forms it is distinguished from *sylvaticus* by its shorter post-molar length and smaller bullæ, and usually by its greater palatal length, longer diastema, and tooth-row. These differences will be appreciated best from an examination of the tables on pp. 518 and 538.

The external and cranial dimensions are given in the tables at pp. 536-9. Further special characters are noted under the sub-species, which are as follows:—

(1) *A. hebridensis hebridensis*, de Winton.

For **Synonymy**, see under species.

Distribution:—Lewis, Outer Hebrides.

Description:—The typical Hebridean Field Mouse differs from *A. s. sylvaticus* in its larger size, stouter build, longer feet, shorter ears, and dull under side. In general size it, when old, about equals *A. f. wintoni*, but its ears are smaller than those of the much smaller *sylvaticus*. A pectoral spot is present and usually rather longer than in *sylvaticus*, but not forming a collar. In **colour** the back and flanks are about as in *sylvaticus*. The typical adults from Uig, western Lewis, collected in September, have the under-parts heavily washed with buff, and show no distinct line of demarcation; the tail is uniformly brownish-grey, and is shorter and thicker relatively than in *sylvaticus*. Attention was called by de Winton (Barrett-Hamilton, *Proc. Zool. Soc.*, London, 1900, 404) to the possible occurrence of **sexual differences** in the pelage of this form; he noticed that "young males appear to lose the dull hues of immaturity of the upper side, and to don the reddish colour of maturity at an earlier age than do the females, so that young males and females of the same age are actually distinguishable by their colour alone." In a series of seven adults collected by Mr Anderson between 5th and 10th April 1913, at Garrynahine, Callernish, western Lewis, the four females are like the Uig specimens, but the males have feeble pectoral spots and but slight trace of an abdominal yellowish wash, while the line of demarcation is rather sharply indicated. The females from Tarbet, Harris, are also like the Uig specimens in colour; as will be seen from the table at p. 536, both these and the mice from Callernish are smaller than the typical series, though the relative size of the feet and ears is the same.

The **skull** differs from that of *sylvaticus* in its larger size, narrower zygomatic, inter-orbital and cranial widths; the bullæ are smaller, the cheek-teeth and diastemata longer—characters which are expressed in the shorter post-molar and longer palatal regions.

Local variation:—Apart from the reduction of size noted above in

THE HARVEST MOUSE (*Micromys minutus*).

(1) LEFT EAR; (2) LEFT HAND; (3) LEFT FOOT; (4) TAIL.
(Three times life size.)

the specimens from Callernish and Tarbet, Harris, there is in eastern Lewis a well-marked deviation from the typical form of Uig. Barrett-Hamilton (*Proc. Zool. Soc.*, London, 1900, 401) referred three small dark specimens from Eisken, eastern Lewis, to his *M. sylvaticus celticus*, and he mentions (*op. cit.*, 395, 403) that de Winton thought that this small form might be an accidental introduction, his *hebridensis* keeping to its own side of the island. The Eisken specimens may have been immature. A series of fourteen adults and two young specimens were collected at Stornoway by Mr D. Anderson in the latter part of March 1913. Apart from the uniform reduction of size which they show when compared with the typical series from Uig, there is little in external appearance to distinguish these specimens from true *hebridensis*. Some of the males are silvery below, like those from Callernish, but in others and in the females there is a more or less well-marked tendency for the lower parts to be suffused with buff. In a young male (head and body, 77) the coat is like that of the adult, having the flanks lighter than the back, the under-surface silvery, with a bright pectoral spot and a paler median wash of buff behind; in a young female (head and body, 78) the flanks are still dark, and though a faint trace of the buff stripe can be seen, the under-surface is greatly darkened by the bases of the hairs (*cf.* p. 532). In average size the skulls are slightly smaller than in typical *hebridensis* (condylo-basal length, 23·64 instead of 24·1 mm.); they are relatively broader and the post-molar length is very slightly increased, the palatal length still more slightly diminished; but in both the latter respects there is substantial agreement with *hebridensis* and considerable difference from any British form of *sylvaticus*. These specimens may eventually have to be separated from *h. hebridensis*, but the separation cannot be made until a much more extensive series of skulls from western Lewis than that at present available has been acquired.

In the few specimens available at present from **Barra** the backs are brighter than in *h. hebridensis*, there being fewer black hairs; the under-surface is silvery, with scarcely a trace of a pectoral spot or buffy suffusion; the line of demarcation is clearly defined. In the single adult skull the small size (condylo-basal length, 23·1) and greater breadths are nearer to the Stornoway series than to typical *hebridensis*; a marked feature is that the palatal length is shorter than in any other form of *hebridensis*, though, on the other hand, such short palates occur occasionally in individuals of the other races.

Two specimens from **South Uist** resemble those from Barra in the slight development of a ventral buffy suffusion; although old, the small size, in particular of the feet, is noteworthy.

Mention may be made here of two field mice taken on **Eigg**, 29th March 1913, by Mr P. D. Montague. Like the grass mouse of the

island (p. 438), these mice have unusually long thick fur; the back is dark; there is a pectoral spot and median wash of buff below—features which are better developed in the male than in the female. The skulls show greater palatal length, a wider masseteric plate, and longer molars than in *h. hebridensis;* but since the teeth are only slightly worn these differences may be due to immaturity. The status of this animal cannot be determined without further material.

(2) *A. hebridensis hamiltoni*, Hinton.

1914. APODEMUS HEBRIDENSIS HAMILTONI, M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, July 1914, 126; described from Rum, Inner Hebrides; type specimen, a male, No. 15.5.28.22 of the British Museum collection.

Distribution:—Confined to the island of Rum.

Description:—This field mouse agrees in general size and proportions with the largest specimens of *A. h. hebridensis*, but has a still larger and a more massive skull. **Colour**:—The backs are about as in *hebridensis;* the ventral surface is silvery, darkened by the hair-bases, with an evident though not very bright pectoral spot, and some slight trace of a yellowish wash; the line of demarcation is a little irregular, and moderately defined. The **skull** is distinguished from that of *h. hebridensis* by its greater size, general narrowness (the nasals, however, being as broad as in the Stornoway series), and greater palatal length. The shoulders of the brain-case are rather strongly ridged in a manner recalling the skull of *A. flavicollis wintoni*, from which, however, it is readily distinguished by its much smaller bullæ, greater palatal length, and longer incisive foramina.

For external and cranial dimensions, see tables at pp. 537 and 538 respectively.

(3) *A. hebridensis cumbræ*, Hinton.

1914. APODEMUS HEBRIDENSIS CUMBRÆ, M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, July 1914, 128; described from Great Cumbrae, Inner Hebrides; type specimen, a female, No. 15.5.29.26 of British Museum collection.

1913. APODEMUS SYLVATICUS SYLVATICUS, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Proc. Zool. Soc.*, London, 1913, 835 (in part).

Distribution:—The island of Great Cumbrae, Inner Hebrides.

Description:—This mouse is smaller than typical *hebridensis*, in size about as *s. sylvaticus;* the tail and ears are relatively longer, the feet relatively as large as in *h. hebridensis.* **Colour** of back rufous, with very few black hairs; the belly is silver, with hardly a trace of the pectoral spot; the line of demarcation is clear, but owing to the light colour of the flanks, the contrast is not very striking. The **skull** is scarcely larger than in *s. sylvaticus*, but it agrees in all essential respects with that of *hebridensis;* it differs from *h. hebridensis* in having the inter-

orbital region narrower, the brain-case broader and deeper, and the nasals, diastemata, and incisive foramina a little shorter.

Related forms:—Similarly rufous, but larger forms are known from the islands of Gigha and Tiree (*Proc. Zool. Soc.*, London, 1913, 836, where they were referred to *A. s. sylvaticus*). The only specimen from **Gigha**, an old nursing female, has the back and flanks slightly darker and a much more clearly defined line of demarcation; the tail is relatively shorter. The specimens from **Tiree** are externally much larger, with considerably shorter tails and ears than in *cumbræ*, which, however, they strongly resemble in colour and the small size of the skull; in the latter the palatal length is slightly increased.

(4) *A. hebridensis maclean*, Hinton.

1914. APODEMUS HEBRIDENSIS MACLEAN, Hinton, *Ann. and Mag. Nat. Hist.*, July 1914, 129; described from Mull, Inner Hebrides; type specimen, a male, No. 15.5.29.27 of British Museum collection.

1913. APODEMUS SYLVATICUS SYLVATICUS, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Proc. Zool. Soc.*, London, 1913, 836 (in part).

Distribution:—The island of Mull, Inner Hebrides.

Description:—Size, and proportions of feet, tail, and ears nearly as in *h. hebridensis*; **colour** much darker than in *cumbræ*, the back clouded by relatively numerous long black hairs; flanks rather light, becoming more pallid below; ventral surface nearly clear silver, with at the most only a feeble trace of the pectoral spot; the line of demarcation is somewhat irregular, and not at all sharply defined. The **skull** approaches that of *h. hebridensis* in size, differing in its exceptionally narrow zygomatic arches, slightly narrower inter-orbital region and brain-case, the latter a little more depressed, and smaller bullæ.

Closely related forms:—The field mice of **Jura** (referred *Proc. Zool. Soc.*, London, 1913, 836, to *A. s. sylvaticus*), judging from three specimens collected in May, have shorter tails and are still darker than those of Mull. In them the back is heavily clouded with black and the flanks are dark; the under-parts are clear silver with a very slight trace of the pectoral spot; the line of demarcation is straight and sharply defined. The skull has wider zygomatic arches, broader and deeper brain-case, longer pterygoid fossæ, shorter nasals and diastemata, and broader incisive foramina and masseteric plates; in some of these cranial features the Jura mice make a nearer approach to *h. hebridensis* than does *maclean*, although in coloration they depart further from the typical form.

Specimens from **Islay**, collected in May and August (at first referred, *loc. cit.*, to *A. s. sylvaticus*), are much like *maclean* in general appearance and colour; they are, however, slightly smaller, with smaller feet, relatively longer ears and tail. The **skull** is distinguished by its

smaller size, the average (although large ones occur) being not greater than in *s. sylvaticus;* in its greater zygomatic and inter-orbital widths, broader and deeper brain-case, and larger bullæ, it makes a still nearer approach to *h. hebridensis* than does the Jura form.

(5) *A. hebridensis fiolagan*, Hinton.

1914. APODEMUS HEBRIDENSIS FIOLAGAN, Hinton, *Ann. and Mag. Nat. Hist.*, July 1914, 131; described from the island of Arran, Inner Hebrides; type specimen, a male, No. 15.5.29.16 of the British Museum collection.

1913. APODEMUS SYLVATICUS SYLVATICUS, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Proc. Zool. Soc.*, London, 1913, 835.

Celtic name:—(Local; in Arran)—*Fiolagan* (Alston).

Distribution:—The island of Arran, Inner Hebrides.

Description:—This is a large mouse approaching *h. hebridensis* in size, in which the feet and tail are rather shorter, and the ears no larger than in the typical form. In **colour** the back is rather rufous, though considerably darker than in *cumbræ;* the ventral surface is (in the typical series of eight from Brodick, Arran) silver, darkened slightly by the bases of the hairs, with hardly a trace of the pectoral spot; the line of demarcation is clearly defined. In a female from the cliffs near King's Caves, Arran, there is a bright pectoral spot which is continued backwards as a median wash of yellow. The **skull** is a little smaller than in *h. hebridensis*, though larger than in *cumbræ;* its chief peculiarity is the unusual lengthening of the pterygoid region, the post-molar length being long, as in the skulls from Tiree and Jura, while the bullæ are relatively smaller than in any other sub-species of *hebridensis;* it differs from *h. hebridensis* further in the slightly wider nasals, slightly greater palatal length, shorter diastemata, smaller incisive foramina, broader masseteric plates, and longer molar series. The differences noted appear to be correlated with the greater muscular needs of a rather more powerful dentition.

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without hairs).	Hind foot (without claws).	Ear.
A. hebridensis hebridensis.				
LEWIS, UIG—Collected by W. E. de Winton:—				
1. Male (the type), 8th Aug. 1894	106	96	25	16
2. Do. 28th Aug. 1894	112	100	25	16
3. Female, 29th Aug. 1894	108	95	23·5	15
Maximum and minimum of 7 (3 males, 4 females) immature or adolescent	96	82	24	18·5
Aug. and Sept. 1894	85	77	23·5	14·5
GARRYNAHINE, CALLERNISH, W. LEWIS—Collected by D. Anderson, 5th to 10th April 1913; average of 7	90·43	85·8	23	14·8
Maximum (male)	98	95	24	14·5(15)

DIMENSIONS IN MILLIMETRES—*continued*:—

	Head and body.	Tail (without hairs).	Hind foot (without claws).	Ear.
A. hebridensis, hebridensis—contd.				
TARBET, HARRIS—D. Anderson:—				
1. Female, 20th April 1913 . . .	90	83	22·5	14·5
2. Do. 21st April 1913 . . .	85	79	23·5	14·5
STORNOWAY, N.E. LEWIS—D. Anderson:—				
Average of 14, March 1913 . . .	95·85	87·8	23·25	15·2
Maximum (male)	102	90	24	16
BUTT OF LEWIS—W. Eagle Clarke:—				
Adult pelage: 1. Male, 29th Sept. 1914 .	89·5	83	24	..
2. Do. 29th Sept. 1914 .	94·5	85·5	23·75	14·75
3. Female, 17th Sept. 1914	99·5	83·5	22·5	15
BARRA—(?*Sub-species*).				
1. Male (Col. Pinney). 8th Sept. 1895 .	99	84	24	15
2. ? (W. E. Clarke), 21st May 1906 .	102	91	23·5	15
SOUTH UIST—(?*Sub-species*).				
1. Male (D. Anderson), 14th May 1913 .	91	86	22	15[1]
2. Female (W. E. Clarke), 1st June 1906	90	80	21	15
EIGG—(?*Sub-species*).				
Collected by P. D. Montague:—				
1. Male, 29th March 1913 . . .	85	78	23	15[2]
2. Female, 29th March 1913 . . .	90	78	23	15
A. hebridensis hamiltoni.				
RUM—Five collected by D. Anderson, 5th to 7th June 1913:—				
Male	105	91	24	15
Do.	95	89	24	15[3]
Female	110	91	24	15
Do.	105	100	25	16
Do.	104	97	24	15
Average of 5	103·8	95·6	24·2	15·2
A. hebridensis cumbræ.				
GREAT CUMBRAE—Collected by R. W. Sheppard:—				
1. Male (max. of series), 29th March 1912	95	92	23	16
2. Female (type), 29th March 1912 .	93	90	23	15
Average of 6 (4 male, 2 female) . .	93	90·3	22·8	15·4
GIGHA—(?*Sub-species*).				
1. Female (R. W. Sheppard), 22nd May 1912	100	85	22·5	15
TIREE—(?*Sub-species*).				
Average of 4 collected by Sheppard, 8th to 13th July 1912	102·5	84·25	23·1	13·5
Average of 6 in Royal Scottish Museum, collected Nov. 1906 and Feb. 1907 .	83·4	84·8	19·2	14·2
Maximum (male), 10th July 1912 . .	105	8[illegible]	24	13(13·5)
A. hebridensis maclean.				
MULL—Five males collected by Sheppard in June 1912:—				
1. Type, 22nd June	100	80	24	14·5
Average	97	87·4	23·2	14·4
Maximum	100	87 (92)	24	14·5(15)
JURA—(?*Sub-species*).				
Average of 3 collected by Sheppard in May 1912	97·6	78·5	22·6	14·5
Maximum (male)	100	(84)	22 (24)	14·5
ISLAY—(?*Sub-species*)				
Average of 9 (Sheppard and Royal Scottish Museum)	93·3	81·6	22·5	14
Maximum (female)	101	85 (88)	22(23·5)	14·5(15)
A. hebridensis fiolagan.				
ARRAN—Nine collected by Sheppard in April 1913:—				
1. Male, 4th April (Type) . . .	105	83	24	15
Average	98·3	84·5	23·5	14·5

[1] Old, teeth much worn. [2] Not fully mature. [3] Type.

Habits:—In habits *A. hebridensis* is doubtless similar to *A. sylvaticus.* In Lewis the country people told de Winton (*Ann. Scott. Nat. Hist.*, 1895, 53) that mice entered their houses in the winter; they were unable to distinguish de Winton's specimens from these visitors.

CRANIAL DIMENSIONS OF *APODEMUS HEBRIDENSIS, HIRTENSIS,* AND *FRIDARIENSIS*:—

	APODEMUS HEBRIDENSIS.					*A. HIRTENSIS.*	*A. FRIDARIENSIS.*	
	hebridensis, W. Lewis.	*hamiltoni*, Rum.	*cumbræ*, Gt. Cumbrae.	*maclean*, Mull.	*fiolagan*, Arran.	St Kilda.	*fridariensis*, Fair Isle.	*grantii*, Mid Yell.
Number of Skulls measured:—	3	2	3	3	6	4	2	7
1. Condylo-basal length	23·5 to 24·7	25·1 25·5	22·8 to 23·5	23·2 to 24·2	22·6 to 24	25·5 to 27·1	25·4 25·7	23·3 to 25·1
Do. average	**24·13**	**25·3**	**23·16**	**23·73**	**23·51**	**26·17**	**25·55**	**24·37**
2. Occipito-nasal length	26·0 to 27·3	27·4 27·7	25·3 to 25·7	25·3 to 26·8	25·8 to 26·7	27·8 to 29·1	27·8 28·4	26·0 to 27·5
3. Zygomatic breadth	12·9 ,, 13·7	13·5 13·7	13·0 ,, 13·2	12·8 ,, 13	12·4 ,, 13·6	14·2 ,, 15	14 14	13·0 ,, 14·1
4. Inter-orbital breadth	4·1 ,, 4·3	4·2 4·2	3·8 ,, 4	4·0 ,, 4·2	3·9 ,, 4·4	4·1 ,, 4·3	4·1 4·4	4·0 ,, 4·3
5. Cranial breadth	11·4 ,, 12	12·2 12	11·6 ,, 12	11·3 ,, 11·7	11·5 ,, 11·9	12·5 ,, 12·9	12 12	11·4 ,, 12
6. Cranial depth (middle) . . .	8·2 ,, 8·6	9 9	8·2 (2)	8·1 (3)	8·1 ,, 8·4	8·2 ,, 8·7	8·5 8·4	7·9 ,, 8·6
7. Condyle to m^3	10·7 ,, 11·3	11·3 11·6	10·5 ,, 10·7	10·5 ,, 11·1	10·2 ,, 11·3	11·7 ,, 12·7	12 12	10·8 ,, 11·8
8. Condyle to front of bulla . . .	6·8 ,, 6·6	6·4 6·6	6·1 ,, 6·2	6·0 ,, 6·4	5·5 ,, 6·2	6·7 ,, 7	6·8 6·7	6·1 ,, 6·5
9. Nasal length	9·5 ,, 10·1	10·2 10·1	9·0 ,, 9·8	9·7 ,, 10·2	9·6 ,, 9·7	11·1 ,, 11 4	10·6 10·4	9·3 ,, 10·1
10. Nasal width	2·5 ,, 2·6	2·9 3	2·7 ,, 2·8	2·7 ,, 3	2·7 ,, 3·1	2·9 ,, 3·1	2·6 2·9	2·6 ,, 2·3
11. Palatal length	12·6 ,, 13·5	14 14	12·3 ,, 12·9	12·6 ,, 13·1	12·6 ,, 13·2	14·3 ,, 14·6	13·8 14	12·4 ,, 13·6
12. Diastema	7·0 ,, 7·3	7·5 7·8	6·5 ,, 6·8	6·9 ,, 7·4	6·6 ,, 6 8	7·7 ,, 8·1	7·5 7·5	6·4 ,, 7·4
13. Incisive foramina (length) . . .	5·6 ,, 6	6·2 6·2	5·2 ,, 5·8	5·7 ,, 6	5·2 ,, 5·7	5·9 ,, 6·4	6·2 6·5	5·6 ,, 6·3
14. Incisive foramina (width) . . .	1·7 ,, 1·9	1·9 1·8	1·7 ,, 1·8	1·6 ,, 1·7	1·6 ,, 1·8	1·9 ,, 2·3	1·8 2	1·7 ,, 1·9
15. Rostral breadth	4·3 ,, 4·8	4·8 4·9	4·3 ,, 4·5	4·3 ,, 4·6	4·3 ,, 5	4·5 ,, 4·6	4·5 4·8	4·5 ,, 5·2
16. Masseteric plate (least width) . .	2·4 ,, 2·7	2·6 2·7	2·3 ,, 2·6	2·2 ,, 2·7	2·5 ,, 2·8	2·8 ,, 3·2	3·3 3	2·6 ,, 2·7
17. Maxillary cheek-teeth . . .	3·8 ,, 4	3·9 4·1	3·7 ,, 3·8	3·7 ,, 3·8	3·8 ,, 4·1	4·1 ,, 4·2	3·7 4	3·7 ,, 3·9
Mandible length	15·1 ,, 15·8	16·5 15·6	14·5 ,, 14·6	14·1 ,, 14·7	14·6 ,, 15·2	16·6 ,, 17·5	15·8 16	14·6 ,, 15·5
Mandibular cheek-teeth . . .	3·8 ,, 4	4·1 4	3·6 ,, 3·7	3·6 ,, 3·8	3·7 ,, 4	3·8 ,, 4·2	3·7 3·8	3·6 ,, 3·9

REDUCTIONS: 1. = 100	100	100	100	100	100	100	100	100
2. =	110 to 110·5	109 109	110·5 to 111	109 to 110·5	110 to 111	107·5 to 109	109 110·5	109·5 to 112
Average	**110·33**	**109**	**110 75**	**109·83**	**110·62**	**108·16**	**109·75**	**110·5**
3. =	54·9 to 55·3	54·0 53·8	55·8 to 57	52·4 to 53·7	52 6 to 58·4	55·0 to 56·1	55 54·5	54·1 to 57
Average	**55·16**	**53·9**	**56·56**	**53·03**	**55·43**	**55·5**	**54·75**	**55·36**
4. =	17·4 to 17·8	16·7 16·5	16·35 to 17·5	16·8 to 17·7	16·5 to 18·6	15·5 to 16·9	16·1 17·1	16·2 to 17·6
Average	**17·53**	**16·6**	**16·8**	**17·28**	**17·65**	**16·05**	**16·6**	**16·83**
5. =	48·5 to 49·5	48·6 47	50·8 to 51·2	47 5 to 49	49·0 to 51·3	46·9 to 49	47·2 46·7	46·1 to 50·2
Average	**48·83**	**47·8**	**51**	**48·26**	**49·63**	**48·23**	**46·95**	**48·17**
6. =	34·4 to 35·5	35·9 35·3	35·3 to 35 9	33·4 to 34·8	34·6 to 35·9	31·8 to 33·8	33·4 32·7	32·7 to 34·9
Average	**34·93**	**35·6**	**35·6**	**34·06**	**35·1**	**32·47**	**33·05**	**33·57**
7. =	45·4 to 45·7	45 45·5	45·2 to 46	45·2 to 46·6	45·1 to 47·1	45·9 to 48·1	47·2 46·7	46·0 to 47·3
Average	**45·53**	**45·25**	**45·56**	**45·9**	**46·23**	**46·83**	**46·95**	**46·63**
8. =	25·5 to 28·1	25·5 25·9	26·4 to 26·7	25·6 to 26·4	24·3 to 25·9	25·1 to 26·5	26·7 26·1	25·5 to 27
Average	**26·53**	**25·7**	**26·6**	**25·93**	**25·3**	**25·96**	**26·4**	**26·07**
9. =	40·4 to 41·3	40·6 39·6	39·4 to 41·7	41·6 to 42·1	40·0 to 42·5	42·0 to 43·6	41·7 40·5	39·4 to 40·5
Average	**40·86**	**40·1**	**40·23**	**41 8**	**40·94**	**42·56**	**41·1**	**39·87**
10. =	10·3 to 10 6	11·55 11·8	11·8 to 12·05	11·6 to 12·6	11·4 to 12·9	10·7 to 11 8	10·2 11·3	10·4 to 11·5
Average	**10·46**	**11·67**	**11·91**	**11·93**	**12 1**	**11·36**	**10·75**	**11·08**
11. =	53·6 to 54·6	55·8 55	53·9 to 54·9	53·8 to 54·2	53·3 to 56·2	53·9 to 56·1	54·3 54·4	53·1 to 54·8
Average	**54·23**	**55·4**	**54·33**	**54·03**	**54·63**	**54·9**	**54·35**	**53·97**
12. =	29·5 to 30·1	29·9 30·6	28·5 to 29·3	29·4 to 30·6	27·9 to 29·2	29·5 to 31	29·5 29·2	27·4 to 30·4
Average	**29·8**	**30·25**	**28·9**	**29·9**	**28·48**	**30·15**	**29 35**	**29**
13. =	23·8 to 24·8	24·7 24·3	22·8 to 24·7	24·4 to 25 2	22·6 to 23·7	22·3 to 24·1	24·4 25·3	24·0 to 25·5
Average	**24·13**	**24·5**	**23·56**	**24·7**	**23·15**	**23·37**	**24·85**	**24·77**
14. =	7·25 to 7·7	7·57 7·1	7·2 to 7·9	6·7 to 7	6·7 to 8	7·2 to 8·5	7·1 7·8	6·9 to 8·15
Average	**7·46**	**7·33**	**7·46**	**6·86**	**7·32**	**7·83**	**7·45**	**7·35**
15. =	18·3 to 19·4	19·1 19·2	18·5 to 19 7	18·1 to 19·4	18·4 to 20·9	16·6 to 17·7	17·7 18·7	19·1 to 21
Average	**18·76**	**19·15**	**18·96**	**18·83**	**19 53**	**17·3**	**18·2**	**19·93**
16. =	10·2 to 10·9	10·35 10·6	9·8 to 11·2	9·5 to 11·2	10·6 to 12·4	10·6 to 11·8	13 11·7	10·4 to 11·15
Average	**10·46**	**10·47**	**10·66**	**10 26**	**11·28**	**11·27**	**12·35**	**10·73**
17. =	15·7 to 16·2	15·5 16·1	16·2 to 16·35	15·5 to 16·4	15 8 to 17·1	15·5 to 16·1	14·6 15·6	15·0 to 16·7
Average	**16·03**	**15·8**	**16·25**	**16**	**16·6**	**15·85**	**15·1**	**15·6**

THE ST KILDA FIELD MOUSE

APODEMUS HIRTENSIS, Barrett-Hamilton.

1899. MUS HIRTENSIS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 1899, 81, pl. ix., fig. 1, reprinted in *Ann. Scott. Nat. Hist.*, 1899, 129; described from St Kilda: type specimen No. 94.7.16.1 of British Museum collection, Barrett-Hamilton, *Ann. Scott. Nat. Hist.*, 1906, i.; (*Apodemus*) Miller, *Catalogue*, 825, 1912.

1900. MUS SYLVATICUS HIRTENSIS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 1900, 404; Johnston; Millais; Trouessart.

Distribution and history:—This field mouse is only known from St Kilda, upon which mice of some sort have been long known to exist (Seton, *St Kilda, Past and Present*, 1878, 132); it inhabits the main island—Hirta—and the adjacent islets, Soay and Dun. Steele Elliott, in an account of a visit to St Kilda given at a meeting of the Birmingham Nat. Hist. and Philosophical Society on 13th November 1894 (*Proceedings*, April 1895, 135; and *Zoologist*, 1895, 282), mentioned the occurrence of a peculiar field mouse on the island. Unfortunately he secured only one specimen—"by far the most interesting of all my captures"—which was placed in spirit and forwarded to Harting. It was thought advisable to wait for further specimens before deciding on the status of this animal; but, for some reason, Harting failed to record the capture in the *Zoologist*. In January 1895 de Winton mentioned (*Ann. Scott. Nat. Hist.*, 1895, 53) the occurrence of "The Wood-Mouse (*Mus sylvaticus*)" on St Kilda. Later, when de Winton described his *Mus hebridensis* (*Zoologist*, October 1895, 369), Steele Elliott, not suspecting the possibility that *hirtensis* and *hebridensis* might be distinct, wrote (*Journ. cit.*, 1895, 426, and 1896, 76) claiming priority for the discovery. De Winton at once pointed out (*Journ. cit.*, 1895, 446) that his own description of *hebridensis* was not applicable to the mouse taken by Steele Elliott at St Kilda. In 1898 Barrett-Hamilton's interest was awakened by the remarkable appearance of Steele Elliott's mouse, and he induced Henry Evans to land on St Kilda and trap further specimens. On the material so obtained Barrett-Hamilton based his *Mus hirtensis*.[1] The habits of this mouse have been described by J. Waterston (*Ann. Scott. Nat. Hist.*, 1905, 199), and Eagle Clarke's recent work has greatly extended our knowledge of it (*Journ. cit.*, June 1914, 124).

Description:—*A. hirtensis* is a large mouse with long feet and rather short ears, distinguished from its closest ally, *A. hebridensis*, by its larger size, relatively longer ears, occasionally darker ventral coloration, and considerably larger skull.

The **colour** of the back and flanks is nearly as in *sylvaticus*; the under-surface is sometimes heavily washed with buff or yellowish-brown, which tint merges laterally in that of the flanks, so that there is no well-defined line of demarcation. It seems, however, that this is not the

[1] Barrett-Hamilton, *Ann. Scott. Nat. Hist.*, 1906, 1.

normal coloration, for Mr Eagle Clarke has found (*op. cit.*), from a long series of specimens taken in the months of September and October, that in about two-thirds of the adults, "and many of the immature ones, the throat, chest, and abdomen are white, and only washed with brown along the narrow median ventral line. As a result the demarcation between the peppery reddish-brown upper-, and the pale under-surface is pronounced in most examples, and renders the species very similar to" *A. sylvaticus.* "About one-third of the adults and the majority of the younger specimens have the under-surface more or less strongly washed with buff." The dark dorsal line is well developed. In young individuals the backs are greyer, the bellies more rufous than in adults (see Steele Elliott's description of the type specimen, *Zoologist*, 1895, 426). In the **skull** the smooth and rounded brain-case is rather depressed; the post-molar length is not shortened as is usual in *hebridensis*, though the bullæ are rather small; and the nasals are relatively long (see proportional measurements in the table at p. 538). The **cheek-teeth** are as in *sylvaticus.*

Dimensions:—

	Head and body.	Tail.	Hind foot.	Ear.	Condylo-basal length.
1. Male, immature (type of species, No. 94.7.16.1 of British Museum collection)	81	85	25	..	24·5
2 Male, Henry Evans . . .	107	91	24·5	17	23[1]
3. Male, largest recorded by W. Eagle Clarke	129	109	26·5	17·5	..
4. Female, Henry Evans . . .	110	94	24	15 (?)	..
5. Female, largest recorded by W. Eagle Clarke	126	110	25·5	19·5	..
6. Average—20 males (Eagle Clark) . .	109·8	94	25·1	17·5	..
7. Average—22 females (Eagle Clark) .	112	107	24·9	17·2	..

[1] Cheek-teeth only slightly worn.

Remarks:—Specimens with head and body between 100 and 113 mm. are probably adolescent; full-grown (which in most *Muridæ* means "senile") specimens are those with the head and body near 120 mm.

For cranial dimensions, see table at p. 538 above.

Status:—*A. hirtensis* is a well-marked member of the *sylvaticus* group. The latter has been established in Britain since the late Pliocene (Forest Bed), a fact which goes far to support the view that this species is truly indigenous upon St Kilda. The characters of *A. hirtensis* are probably to be regarded as the results of insular specialisation. For remarks upon the position of *hirtensis* within the *sylvaticus* group, see above under Genus.

Habits:—Mr Eagle Clark says that this mouse is most abundant where coarse grass prevails, although it is to be found almost everywhere, as in the crofted area, the neighbourhood of houses, on the faces of the cliffs, and on the sides and tops of the hills. It finds congenial retreats in the rough stone-built "cleits," and in the walls surrounding

the crofts. Some fine specimens were captured in a store close to the water's edge. On the island of Dun it was found dwelling in fissures and holes on the face of the rocks, where the very luxuriant grass was growing close by on ledges or at the foot of the crags. Here its presence was betrayed by its numerous runs, and by the seeds of grass on which it feeds. Seeds of *Carex flava* were found in a hole a few inches deep on a hillside in Hirta; these seeds form perhaps the chief food. It appears to be much addicted to cannibalism; because of this, many specimens were completely destroyed before the traps could be visited. It appeared to be entirely nocturnal. Like *sylvaticus* and other mice, it attains sexual maturity at an early moment; the nursing females caught in September 1910 and 1911 varied greatly in size, some being evidently quite young creatures. In September 1910 no pregnant females and no young smaller than half-grown were taken. In September 1911 Mr Eagle Clark obtained several quite young mice. A female caught on 14th September contained seven fœtuses; another younger one taken on the 18th, had six less developed fœtuses. Mr Waterston describes two nests, "neither of them typical." He found males twice as numerous as females. Dissections showed the average number of fœtuses to be six. Both sexes appeared to be subject to disease, especially of the liver, which was spotted by colonies of *coccidia*, and also infested by a Cestode. The people said that on Dun these mice are subject to variation in colour, and one with some white markings was brought to Mr Waterston.

THE FAIR ISLE FIELD MOUSE.

APODEMUS FRIDARIENSIS (Kinnear).

Synonymy under sub-species.

Distribution:—Fair Isle and Shetland Islands, where it occurs on Yell, and possibly on Mainland.

History and status:—This Field Mouse was discovered on Fair Isle by Kinnear, who described it in 1906 as a sub-species of *A. sylvaticus*. In his *Catalogue* Miller has accorded this form full specific rank. The differences between *fridariensis* and *sylvaticus* are scarcely such as would entitle the former, if it stood alone, to be considered as anything more than a sub-species of the latter. In the summer of 1913, Ogilvie-Grant found a Field Mouse living on the island of Yell. His specimens, although differing from typical *fridariensis* in some respects, are clearly more nearly related to the Fair Isle mouse than to *A. sylvaticus*, and they have been described as a sub-species (*A. f. grantii*). A large Field Mouse also occurs on Mainland, Shetland, and this, when better known, will probably be found to belong to

fridariensis also. It is, therefore, useful to retain *fridariensis* as a full species, because by doing so we are enabled to indicate the relationship of these insular Field Mice in a convenient manner.

As Kinnear pointed out, *A. fridariensis* has branched off from *A. sylvaticus* in a different direction from that followed by the Hebridean species, *hebridensis* and *hirtensis;* in the present species there is no increase in the relative size of the foot, and the ventral surface shows no tendency to become buff, and so cause the obliteration of the line of demarcation.

Description :—*A. fridariensis* differs from *A. sylvaticus* externally in its larger size, darker coloration, shorter ears, and relatively smaller palmar and plantar pads. The skull is characterised by its exceptionally slender rostrum; in the mandible the coronoid processes are usually small. Further details will be found below under the sub-species.

(1) *Apodemus fridariensis fridariensis* (Kinnear).

1906. MUS SYLVATICUS FRIDARIENSIS, N. B. Kinnear, *Ann. Scott. Nat. Hist.*, April 1906, 68; type a male in the Royal Scottish Museum, Edinburgh; described from Fair Isle, Shetlands; Trouessart.

1912. APODEMUS FRIDARIENSIS, G. S. Miller, *Catalogue of the Mammals of Western Europe*, 825.

1914. A(PODEMUS) F(RIDARIENSIS) FRIDARIENSIS, M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, July 1914, 132.

Distribution :—Fair Isle.

Description :—The general colour of the upper parts is like that of *A. sylvaticus*, but the long black hairs of the back and flanks are more numerous and give the fur a looser and harsher texture; these hairs cause the back to be more conspicuously clouded with black, and impart to the flanks a much darker, richer, and more heavily lined appearance. The line of demarcation along each flank is very regular in its course and very clearly defined. The ventral surface is of a uniform dull bluish-white throughout; it shows no trace of a buffy suffusion, and usually no trace of a pectoral spot; the latter is occasionally represented by a few brownish hairs. The feet are whitish. The upper surface of the tail is dusky, in sharp contrast with its whitish lower surface.

The skull is large, and has the brain-case relatively long and narrow; the temporal ridges are occasionally (*e.g.*, B.M., 6.11.18.4) sharply defined in old age, although they never impart such an angular appearance as is seen in old skulls of *A. flavicollis*. The rostrum is long and slender; the masseteric plates of the zygomata are relatively broad, and project further in advance of the upper zygomatic roots than they do in *A. sylvaticus*. The coronoid processes of the mandible are very short and slender. The cheek-teeth are as in *A. sylvaticus*.

For external dimensions, see table at p. 544; the cranial measurements are given above in the table at p. 538.

(2) *Apodemus fridariensis grantii* (Hinton).

1914. APODEMUS FRIDARIENSIS GRANTII, M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, July 1914, 132; type an old male, No. 15.5.31.4 of British Museum collection; described from the island of Yell, Shetland.

Local name:—*Hill Mouse.*

Distribution:—Yell, and possibly Mainland, Shetland.

Description:—This sub-species is distinguished from typical *A. fridariensis* by its slightly smaller size and relatively shorter tail. In colour it is quite like the typical form, save that a small pectoral spot appears to be constantly present, and the contrast between the upper and lower surfaces of the tail is much less striking. The line of demarcation on each flank is very regular and distinct.

The skull is slightly smaller than in the Fair Isle form. The brain-case is shorter and rounder, more like that of *sylvaticus* in form; the nasals slope more gently forwards, and the dorsal profile appears to be flatter and less convex throughout. The masseteric plates of the zygomata are much narrower and do not project so far in advance of the bridges over the infra-orbital canals. The bullæ are smaller. In the mandible the coronoid processes are even more slender; the angular processes are exceptionally long, and specimens may be readily distinguished by this character from the mandibulæ of all other European forms of *Apodemus*. For external and cranial dimensions, see tables below and at p. 538 respectively.

DIMENSIONS IN MILLIMETRES:—

	Head and Body.	Tail (without hairs).	Hind foot (without claws).	Ear.	Weight in grammes.
FAIR ISLE.—*A. fridariensis fridariensis*:—					
1. Male (N. B. Kinnear), paratype, 5th Sept. 1905	115	106	23	15	35
2. Do. do. 9th Sept. 1906	113	102	24	17	..
3. Do. do. 16th May 1906	106	..	24	16	..
4. Do. (Duchess of Bedford), 10th Oct. 1910	107	105	25	16	..
5. Female (N. B. Kinnear), 14th Sept. 1906	111	..	24	17	..
6. Do. (Duchess of Bedford), 10th Oct. 1910	105	100	25	16	..
7. Do. do. 10th Oct. 1910	99	95	25	16	..
YELL, SHETLAND.—*A. f. grantii*:—					
1. Male (W. R. Ogilvie-Grant), 22nd June 1913	104	91	23	16·5	..
2. Do. do. 22nd June 1913	100·5	87	23	16·5	..
3. Do. do. 25th June 1913	98	79	24	15·5	..
4. Do. do. 25th June 1913	105	80	25	15·5	(Type)
5. Do. do. 22nd June 1914	99	96	24·5	16	..
6. Do. do. 25th June 1914	110	94	25	17	..
7. Do. do. 25th June 1914	106	92	24	16	..
8. Do. do. 25th June 1914	102	100·5	24	17·5	..
9. Female, do. 22nd June 1913	97	96	23	15·5	..
10. Do. do. 22nd June 1914	94	92	24	15·75	..
Average of 6 adults of *A. f. fridariensis* .	109·5	103·2	24·1	16·1	..
Average of 10 adults of *A. f. grantii* . .	101·5	91·75	23·95	16·17	..

THE YELLOW-NECKED FIELD MOUSE.

APODEMUS FLAVICOLLIS (Melchior).

1834. MUS FLAVICOLLIS, Melchior, *Den Danske Staats og Norges Pattedyr*, 99; described from Sjælland, Denmark; de Winton, *Zoologist*, December 1894, 441; Lydekker; (*Apodemus*) Miller (*Catalogue*).

1874. MUS SYLVATICUS, Lilljeborg, *Sveriges og Norges Ryggradsdjur*, i., 263; Barrett-Hamilton, *Proc. Zool. Soc.*, London, 1900, 404, 406, 408 (in part; sub-species *M. s. typicus, cellarius, princeps, wintoni*); Fatio, Trouessart, Winge, and Collett (all in part).

For full **Synonymy** of species and typical sub-species, see Miller's *Catalogue*.

History:—In 1834 Melchior described his *Mus flavicollis* from material collected in Sjælland, Denmark; in 1836 the editor of Wiegmann's *Archiv für Naturgeschichte* (1836, 78), when reviewing Melchior's book, expressed his decided opinion that *A. flavicollis* was nothing but a large variety of *sylvaticus*, and for upwards of sixty years subsequent writers appear to have been satisfied with this opinion, In 1894 de Winton studied some giant Field Mice from Herefordshire and came to the conclusion that they, together with a specimen from Oundle, Northamptonshire, and another from Tharand, Saxony, were distinct from *A. sylvaticus*, and that they were referable to Melchior's species. Barrett-Hamilton, finding that Field Mice from Hilleröd, in Sjælland, Denmark (a locality almost topotypical for *flavicollis*), agreed with typical *sylvaticus* from Upsala, regarded, in 1900, Melchior's name as a synonym of *sylvaticus typicus;* he was not then aware that two forms of Field Mouse were living in Sjælland; at the same time he distinguished, as sub-species of *sylvaticus*, *Mus cellarius*, J. V. Fisher (*Zool. Gart.*, vii., 153, 1866), described from cellars at or near St Petersburg, Russia, and his own *M. s. princeps*, described from Bustenari, Rumania; de Winton's mice were described as a sub-species, *wintoni*, of *sylvaticus* also. With much more material at his disposal Miller has concluded that the giant Field Mouse is specifically distinct from *A. sylvaticus*, and that this large species is the *Mus flavicollis* of Melchior. Miller further regards the British *A. f. wintoni* as a distinct sub-species from the typical *A. f. flavicollis* of the Continent. His views are adopted in the present work.

Two recent authors of great eminence, Winge and Collett, do not think *A. flavicollis* to be a valid species. The former (*Danmarks Pattedyr*, 94) regards *flavicollis* as simply a well-grown *sylvaticus;*[1]

[1] "There does not appear to be any occasion to speak even of a true racial distinction; the difference is most likely dependent upon accidental better or worse condition."

the latter regards it as one of the phases of *sylvaticus*, which "is a polymorphic species." According to both writers, *sylvaticus* and *flavicollis* intergrade; and both may be found mingled in the same colony. Still, the broad fact remains, according to Collett, that in southern Norway the vast majority of the Field Mice of the coastal lowlands are typical *sylvaticus*, the vast majority of those dwelling in the high mountain pastures are typical *flavicollis*, while the intermediate ground between the two situations is the most usual habitat of the intermediate mice. Further, it is a remarkable fact that although Britain has been occupied, but perhaps not continuously, by members of the *sylvaticus* group since the Upper Pliocene (Forest Bed) period, and that although their fossil remains have been found in several horizons of widely different ages, it is not until the late Pleistocene of Ightham that remains of a form (*A. lewisi*, Newton) similar to, if it be not identical with, *flavicollis* are met with. It is also a fact that *A. flavicollis* has not found its way into any of the islands other than Britain. The status of *A. flavicollis* is, as is the case with other Field Mice of the *sylvaticus* type, undoubtedly a difficult thing to determine; but the facts just cited seem to support the opinions of de Winton and Miller. Some small proportional differences in certain regions of the skull, described below, also support the claims of *flavicollis* to specific recognition.

Distribution:—*A. flavicollis* is distributed throughout Central Europe, ranging from at least southern Skandinavia and Finland southwards to the Pyrenees and Alps, and from Britain eastwards to Greece, Rumania, and western Russia. How far to the north its range extends is unknown. It is represented in the Himalayas by close allies, and the range of the group may extend still further eastwards.

In Norway, according to Collett, *A. flavicollis* is the predominant Field Mouse of the wooded valleys of the interior and the adjoining sub-Alpine tracts; *A. sylvaticus*, on the other hand, being restricted principally to the lowland coastal region. Mice which appear to be intermediate in character are met with in the intervening belt of country. *A. flavicollis* ascends to the mountain pastures, or a height of about 3000 feet. From Fatio's description of the Swiss Field Mice (p. 212) it would appear that *flavicollis* is the prevalent mountain form in the Alps; he mentions specimens taken in the Oberland at a height of about 1900 m., and others from the Engadine at about 2500 m.; from the context it would appear that these were *flavicollis* rather than *sylvaticus*.

In **Britain** it is not known to occur further north than Northumberland; the British form is regarded as sub-specifically distinct from the typical continental *flavicollis*.

Distribution in time:—As stated above, no trace of this species

has been discovered in deposits older than the late Pleistocene. A large lower jaw (16·2 mm. long) mentioned by Woldrich (*Sitzungsb. Akad. Wien. math.-nat. Cl.*, 84, Abt. i., 216, 1881) from the fissure deposit of Zuzlawitz, Bohemia, appears to be referable to this species. From Britain, Newton (*Quart. Journ. Geol. Soc.*, l., 195, 1894, and lv. 424, 1899) has described, first under the name of *Mus abbotti* (not of Waterhouse) and subsequently as *Mus lewisi*, remains of a large Field Mouse from the fissure deposit of Ightham (see above). A lower jaw from one of the upper strata of Kent's Cavern, Torquay, yielding a typical assemblage of late Pleistocene rodents, is also referred to *A. lewisi;* and skulls of the same form have been found in strata of similar age in the Happaway Cave, Torquay, and the Wye Cave, Forest of Dean (Hinton, *Ann. and Mag. Nat. Hist.*, June 1915, 582). The fossil species clearly is closely related to *A. flavicollis*, and may well be identical with it; its real status, in the absence of good skull material, cannot at present be determined, and it is better for the moment, therefore, to regard *A. lewisi* as a distinct form.

Description:—The Yellow-necked Field Mouse is distinguished from *A. sylvaticus* by its larger size (head and body of adults, 100 to 115; hind foot, 23 to 27; condylo-basal length of skull, 25 to 28·8 mm.), more intense and purer coloration, and by some cranial characters.

The **colour** of the back and sides is brighter, with redder tints than in *sylvaticus;* the belly is white, without any trace of a buffy suffusion, and the lateral line of demarcation is always sharply defined. The pectoral spot of yellowish-brown is usually larger than in *sylvaticus*, and is often extended laterally so as to form a complete collar.

The **skull** in adult or old animals (teeth half-worn or more) is distinguished from that of *sylvaticus* of equal age by its larger size and more massive build. The temporal ridges are relatively strongly developed, and impart an appearance of angularity to the skull, as a whole, which is never seen in *sylvaticus;* anteriorly these ridges are continued almost to the lachrymal as sharp superciliary margins which are sufficiently salient to produce a slight but evident longitudinal furrow upon the frontals. The auditory bullæ are relatively large. The diastemata are proportionally about as long as in *sylvaticus*, but the incisive foramina are relatively shorter (see table at p. 518 above).

The **cheek-teeth** are a little larger than in *sylvaticus*, but they are of the same form and structure. In m_1 the anterior "accessory" cusp (p. 501 above) is frequently of small size, and is occasionally so inconspicuous that, in moderately worn specimens, it may appear to be quite absent. Newton called attention to this character in his description of the pleistocene *A. lewisi.*

Geographical variation:—Two sub-species are now recognised. One of these, the typical continental form, *A. f. flavicollis*, has the

ventral surface usually of a pure white colour; its pectoral spot is often not sufficiently developed to form a complete collar. The other is the British *A. f. wintoni*, described below. Collett says that in the form living in southern Norway the reddish-yellow pectoral belt is seldom wanting, and that it is often prolonged in a short point down towards the belly; this race would thus appear to make a closer approach towards the British form than do the specimens from Central Europe.

The British sub-species is:—

DE WINTON'S FIELD MOUSE.

APODEMUS FLAVICOLLIS WINTONI (Barrett-Hamilton).

1900. MUS SYLVATICUS WINTONI, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 1900, 406; described from Graftonbury, Herefordshire; type specimen, a male, No. 0.3.12.1 of British Museum collection; Trouessart; Johnston; Millais.

1894. MUS FLAVICOLLIS, de Winton, *Zoologist*, 441, December; Lydekker.

1912. APODEMUS FLAVICOLLIS WINTONI, Miller, *Catalogue*, 831.

History:—Pennant (*Quad.*, ii., 184, ed. 3, 1793)[1] states that the "Field Rat" has the "breast of an ochre colour; belly white; length, from the tip of the nose to the tail, 4½ inches; tail, 4 inches"; this description appears to have been based upon a specimen of the present form, and not upon *sylvaticus*. Similarly, the dimensions given by Shaw, Desmarest, and Bell (ed. 2, 296) appear to be derived from *wintoni*, and most of the older writers seem to have regarded this mouse as a full-grown or finely developed *sylvaticus*. Jenyns (*Man. Brit. Vert.*, 31, 1835), however, called specific attention to "a larger variety, measuring 4½ inches in length, exclusively of the tail, which is 4 inches," sometimes met with in woods. The history of modern knowledge of this form, dating from de Winton's paper of 1894, has been dealt with above under the species.

Distribution:—This mouse is only known from South Britain, in which it appears to have a wide but sporadic distribution. Originally described from Herefordshire and Northamptonshire, it is now known to occur at various localities in Sussex, Surrey, Kent, Middlesex, Essex (Dr H. Laver and G. Dalgleish, *in lit.*), Suffolk (Southwell, *Zoologist*, 1903, 150), Northumberland, Worcestershire (Pocock, *Journ. cit.*, 1901, 423), Cornwall, Shropshire, near Oswestry (Dumville Lees in Forrest), Brecon (at Llyswen, Phillips), and Denbigh (Llanrwst, Forrest, *North Wales*, 50).

Where present this mouse is usually abundant, its colonies being, if

[1] Also in *Brit. Zool.*, ed. 1 (folio), 1766, 49.

always distinct from, frequently in close proximity to those of *sylvaticus*. De Winton (*op. cit.*, 442) states that all the specimens (of both species) of which he records the dimensions "were caught within an area of thirty acres, but the species did not intermingle; yet there was no natural boundary or observable difference in the soil on which they were found." Dalgleish (*in lit.*, 17th November 1910) found it common in parts of Surrey, where it occurred with *sylvaticus*. L. E. Adams (*MS.*) finds it at Reigate associated with *sylvaticus* and with mice which he considers to be intermediate between the two forms.

A. f. wintoni is not known from Scotland, Ireland, nor any of the smaller islands.

The differential distribution of *wintoni* and *sylvaticus* within the British area offers a certain analogy with that of the Common and Pygmy Shrews. The restricted distribution of *wintoni*, coupled with the fact that field mice of this type are not known in Britain before the late Pleistocene, suggests that it is a comparatively recent immigrant. The facts are susceptible of a different explanation, however. The existing English stock of *sylvaticus* is quite possibly no older, since it may also have arrived here in late Pleistocene times (see p. 510 above); the *sylvaticus*-like forms from the Upper Pliocene and the earlier Pleistocene are in all probability distinct. From such earlier and distinct stocks certain of the insular species (e.g. *A. hirtensis*) may well have descended. The wider range of the modern stock of *sylvaticus* in Britain and Ireland may in this case be due merely to some inherent advantage as a colonist possessed by the smaller over the larger species. The fact that in Norway and Switzerland *flavicollis* is the mountain form and *sylvaticus* is the lowland species lends some support to this latter hypothesis. Further close anatomical and palæontological research will probably throw light on this interesting question.

Description:—*A. f. wintoni* usually possesses a well-defined and complete ochraceous breast-band or collar "about 8 mm. broad, passing along the chest immediately in front of the fore legs, with a cross or longitudinal stripe in the centre extending forward about 5 mm., and back along the sternum about 10 mm., where it is entirely lost" (de Winton, *op. cit.*, 442). The fur would appear to be somewhat thinner than in the continental form, and the dark bases of the hairs usually impart a more marked slaty tinge to the white under-parts.

Young:—The juvenal pelage is plumbeous, as in *sylvaticus*. De Winton (*op. cit.*, 443) stated that some trace of the pectoral collar could be seen in specimens in this pelage; this is confirmed by Adams, who finds that all young in the first pelage show a collar of a dark shade across the grey chest. Compared with the first pelage of *sylvaticus*, the juvenal coat of *wintoni* is much whiter ventrally (L. E. Adams, *MS.*).

The **skull** and **teeth** have been described above under the species. For cranial dimensions, see table at p. 518.

De Winton (*op. cit.*, 443) mentions that the tail is made up of 30 vertebræ, instead of 27 as in *sylvaticus;* but de l'Isle (*Ann. Sci. Nat. Zool.*, 1865, iv., 215) has pointed out how variable the skeleton of the Field Mouse is in such respects. The tail is stated by Adams (*in lit.*) to be relatively robust as compared with that of *sylvaticus.*

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without hairs).	Hind foot (without claws).	Ear.	Weight in grammes.
SEXUALLY IMMATURE (OF BOTH SEXES):—					
Caught and measured by L. E. Adams—					
1. Female, in first pelage, 10th Oct. 1911	68	64	20·5	..	..
2. Male, do. 25th July 1911	69	71	21	13	10
3. Do. do. 29th Oct. 1909	70	70	20·5	..	..
4. Do. do. 9th July 1909	72	73	22	..	..
5. Female, pelage changing, 7th Aug. 1909	86	92	23	..	..
6. Male, do. 10th Feb. 1905	89	85	25	..	..
7. Female, do. 30th Dec. 1904	90	78	23	..	20
8. Male, do. 8th June 1909	91	100	22	..	..
9. Do. pelage almost ad., 27th Feb. 1905	95	92	25	..	22[1]
10. Female, imperforate but perhaps adult, Ludlow, Salop, 1st March 1913	104	108	23	17	31
Herefordshire, young in grey pelage (de Winton, *Zoologist*, 1895, p. 370), male .	68	60	20	16	..
Do. do. female	81	84	21	16	..
Do. do. do.	84	83	22	16	..
Do. do. male	90	83	24	17	..
SEXUALLY MATURE MALES:—					
Caught and measured by L. E. Adams at Reigate, Surrey—					
1. 10th Dec. 1904	117	115	25	..	34
2. 30th Dec. 1904	117	116	25	..	35·5
3. 8th June 1909	91	100	22	..	..
4. 26th June 1909	114	124	24·5	..	..
5. 9th July 1909	103	112	24	..	..
6. 11th July 1909	98	108	24	..	..
7. 27th Sept. 1909	98	106	24	..	..
8. 8th Oct. 1909	100	114	25	..	..
9. 29th Oct. 1909	103	110	25	..	..
10. 29th Oct. 1909	100	108	24	..	..
11. 29th Oct. 1909	94	94	23	..	..
12. 3rd Dec. 1909	93	102	24	..	..
13. 7th Dec. 1909	95	98	23	..	..
14. 7th March 1910	103	112	23·5	..	..
Bishop's Stortford—					
15. 8th May 1911	104	118	22·5	..	..
16. 26th May 1911	114	122	24	..	34
17. 26th May 1911	106	118	24	..	..
Reigate—					
18. 24th May 1912	100	120	24	17	32
Ludlow, Salop—					
19. 1st March 1913	105	97	23	16	33
Herefordshire (W. E. de Winton, *Zoologist*, 1895, p. 370)	110	112	24	18	..
Richmond Hill, Surrey (G. Dalgleish, *Zoologist*, Nov. 1904, p. 425)	119	115	25	..	33·6[2]
Woolpit, Suffolk (W. D. Parker) . .	112	120	24	..	..
Average of 22 (approximate) . .	105	110·8	24	17	33·7

[1] Testes quite small; pelage almost adult.

[2] Tail imperfect, foot with claws: neither included in average; weight stated as "1 oz., plus 1 shilling piece" = $1\frac{3}{16}$ oz.

DIMENSIONS IN MILLIMETRES—*continued*:—

	Head and body.	Tail (without hairs).	Hind foot (without claws).	Ear.	Weight in grammes.
SEXUALLY MATURE FEMALES:—					
Caught and measured by L. E. Adams at Reigate, Surrey—					
1. 30th Dec. 1904	100	100	23	..	28
2. 24th Aug. 1906	85	98	24	..	22
3. 22nd July 1909	90	104	22	..	..[1]
4. 10th Oct. 1911	94	108	23	16	31[2]
Ludlow, Salop—					
5. 1st March 1913	105	107	24	17	31[3]
Herefordshire (W. E. de Winton, *Zoologist*, 1895, p. 370)	108	108	24	18	..
Do. do.	110	115	23	18	..
Do. do.	115	112	24	18	..
Norton, Worcestershire (R. I. Pocock, *Zoologist*, 1901, p. 423), in spring	108	114	22	19	..
South Herefordshire (G. A. Burney), 28th March 1914	101	100	23	15·5	..
Average of 10	101·6	106·6	23·2	16·5	..
Graftonbury, Hereford: average and extreme measurements of 6 adults of both sexes; Miller, *Catalogue*:—					
Minimum	102	92	23	17	..
Maximum	115	115	25	19	..
Average	108·6	107·5	24·1	17·6	..

[1] 6 embryos. [2] Suckling. [3] Perforate; practically mature.

Habits:—The general habits of this mouse are, no doubt, like those of *sylvaticus*. Not infrequently, however, it takes up an abode in houses. Thus Mr Adams says that it "occasionally frequents buildings"; Dr H. Laver informed us of four that were killed in a storeroom at Colchester in 1904; Mr G. Dalgleish (*in lit.*) describes three females caught in a storeroom in his house at Midhurst, Sussex, early in November 1910, and he states that in the winter of 1909 a number were taken in an outhouse, where potatoes were stored, at Godalming, Surrey. Lastly, Mr J. F. Davison sent three caught on 26th February 1913 in a ground-floor room, used as a larder, in his house at Ludlow, Shropshire; he mentions (*in lit.*) that he had also caught this mouse, together with *Microtus hirtus*, in the cellars; that in one part of his stables *wintoni* abounded, while next door, and

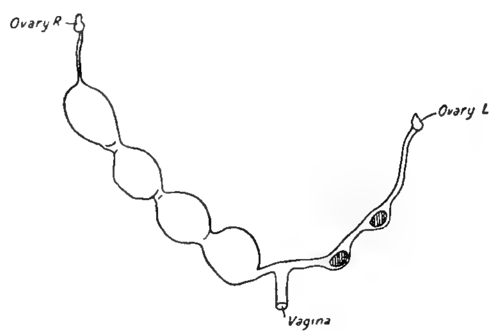


FIG. 88.—*A. f. wintoni:* DISSECTION OF UTERUS, SHOWING SUPERFŒTATION. (L. E. Adams.)

in the kitchen of the house itself, there seemed to be nothing but rats in plenty.

Like *A. sylvaticus, wintoni* probably breeds throughout the greater part of the year. Mr Adams has found new-born young in July, October, and November; he once met with a litter of six. We are indebted to the same gentleman for a sketch of what appears to be a well-marked case of superfœtation (Fig. 88); the right uterine cornu contained four relatively well-developed embryos, while in the left cornu were two much smaller.[1]

According to Melchior, the typical form lays up winter stores and sometimes enters houses and corn-ricks in winter. Its pairing season begins in February and continues at intervals throughout the summer, there being from four to eight young in a litter. He makes the remarkable assertion that if a female be the tenant of a room and without a mate, she will pair with the House Mouse; the progeny of such a union are described as recognisable hybrids showing some similarity to each parent, but being characterised constantly by their long hind feet and dark-coloured soles.

Genus MICROMYS.

1841. Micromys, A. Dehne, "*Micromys agilis, kleinmaus, ein neues Säugthier der Fauna von Dresden,*" 1; based on *Micromys agilis* of Dehne=*Mus soricinus* of Hermann=*Micromys minutus soricinus;* Thomas, *Ann. and Mag. Nat. Hist.*, May 1905, 492 (part); Miller (*Catalogue*).

Mus of most writers prior to Thomas, 1905, quoted above.

The genus *Micromys* is now restricted to the Harvest Mice. These are regarded as belonging to a single species, *M. minutus*, which, notwithstanding a wide distribution extending from Britain through the central parts of Europe and Asia to Japan, appears to be subject to surprisingly little geographical variation.

In all the essential features of its organisation this genus is not unlike *Apodemus*, and there can be little doubt, although the positive evidence of fossils is not yet forthcoming, that it is descended from primitive *Apodemus*-like ancestors. *Micromys* is characterised by numerous external and internal features which are apparently the outcome of a peculiar specialisation

[1] Mr Adams writes:—"I sent the specimen to Barrett-Hamilton, and he sent me his opinion that it was not a case of superfœtation, but that the two small embryos had died."

histories of very many others, which were formerly little known, have been fully elucidated, while, speaking generally, an immense increase in our knowledge on such important subjects as Migration, Distribution, Habits, Nidification, Plumages, has accrued: And lastly, a new and important branch of study has been instituted —namely, the recognition of the various Racial Forms or Subspecies exhibited by certain birds in the British Islands, on the Continent, and elsewhere.

A great advance has also been made towards a more satisfactory system of classification of the Aves—always a difficult subject—and this necessitates departures from the older views.

To bring this Standard Work thoroughly abreast of the most recent knowledge in all these departments is the object of the present work.

It should be remarked that while it is not intended to go fully into Synonomy, yet, where changes of nomenclature have been necessary in order to conform with the Law of Priority—the only method by which complete uniformity in nomenclature can ultimately be attained—the names used in the Fourth Edition of Yarrell's "British Birds" and in Saunders' "Manual," and the Trinomial Names of the British Racial Forms, and of those occurring in Britain as visitors from the Continent, will be quoted, as will also the Original Name under which the species was described.

In requesting Mr Eagle Clarke to undertake the duties of Editorship, the Publishers desire to make it known that they are acting under the advice of the late Mr Howard Saunders, who placed all his collected notes for a New Edition at Mr Eagle Clarke's disposal for this purpose. That Mr Eagle Clarke is eminently fitted for the work is well known to all who are interested in ornithological science. Through his investigations of the subject, and contributions to its literature, he has long been recognised as one of the foremost authorities on all that relates to British birds. He has studied our native birds in many portions of the British Islands, and has visited a number of bird-haunts in various parts of Europe in order to become acquainted in their Continental homes with the visitants that seek our shores.

On the important matter of the Migrations performed by British Birds, Mr Eagle Clarke's knowledge is unrivalled—a material fact, when it is called to mind how little has been said on this most important subject in any published History of British Birds.

A new and important feature of the New Work will be a Coloured Plate of each species. These will be reproduced in the best style from original drawings specially executed for the work by Miss Lilian Medland, F.Z.S., an accomplished and well-known bird artist.

GURNEY & JACKSON

33 PATERNOSTER ROW, LONDON, E.C.

Oliver and Boyd, Printers, Edinburgh.

PART XVIII.—February 1916 Price 2s. 6d. net.

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A NEW AND REVISED EDITION OF
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EDITED BY

WILLIAM EAGLE CLARKE, F.R.S.E., F.L.S.

Keeper of the Natural History Department, The Royal Scottish Museum; Member of the British Association Committee on the Migration of Birds as Observed on the British and Irish Coasts; Corresponding Fellow of the American Ornithologists' Union; Correspondirender Mitglied des Ornithologischen Vereins in Wien; Membre Honoraire du Bureau Central Ornithologique Hongrois; Member of the British Ornithologists' Union, etc.

ILLUSTRATED BY ORIGINAL COLOURED PLATES OF EACH SPECIES SPECIALLY EXECUTED BY

MISS LILIAN MEDLAND

THE publication of Yarrell's "History of British Birds" was commenced in 1837 and completed in 1843. Its outstanding merits were at once recognised, and a Second Edition was called for in 1845, followed by a third in 1856.

From the issue of the Original Edition down to the present day, Yarrell's "History of British Birds" has generally and deservedly been regarded as the standard authority on British ornithology.

In the year 1871 a Fourth Edition was begun, under the masterly editorship of Professor Newton—the greatest British ornithologist of all time. Unfortunately Professor Newton's official engagements at the University of Cambridge only allowed him to complete the first two volumes; and in 1882 Mr Howard Saunders was selected to edit the remaining volumes, a task which he successfully accomplished to the entire satisfaction of ornithologists in 1885.

The many excellences of this last edition advanced the work more than ever in the public and in scientific favour. To its stimulating influence is to be mainly attributed the marvellous and unprecedented activity which has resulted in those extraordinary advances made in all branches of British ornithology during recent years—advances which have rendered it essential that a new work based upon this classical and comprehensive foundation should be issued.

During the period alluded to, a considerable number of new and interesting species have been added to our avifauna. The

[Continued on Page 3 of Cover

CONTENTS OF PART XVIII.

The English local names have been revised in part by Mr W. W. Skeat, M.A. (assisted by the late Professor W. W. Skeat), and in part by Mr C. M. Drennan, M.A. Lond., late Scholar Emm. Coll. Camb.; the Celtic and Gaelic names by Dr E. S. Quiggin, M.A., Ph.D., Fellow and Lecturer in Modern Languages and Celtic of Gonville and Caius College, Cambridge; while a list of Scottish Gaelic names has been supplied by Mr C. H. Alston. Much information has been taken from Mr G. S. Miller's recently published "Catalogue of the Mammals of Western Europe," the use of the MS. and proofs of which before publication was kindly permitted by the Trustees of the British Museum of Natural History.

ILLUSTRATIONS

FULL-PAGE (*Coloured and Black and White*).

FIGURES IN TEXT.

fitting it for a life spent largely in climbing the slender stems of grains and grasses. The size is diminutive, and the build elegant and slender; the weight of an adult is scarcely more than one-sixth of that of an adult *A. sylvaticus*.[1] The tail is prehensile (a character unique among British mammals). In the large hands and feet the pads are of large size and somewhat modified form; they serve apparently, as in many other climbing mammals, the purpose of "climbing-irons." In the ear the antitragus is developed as a large triangular valve which is capable of completely closing the meatus. The eyes are smaller and less prominent than in *Apodemus*. In the skull (as in many climbing mammals) the brain-case is relatively large; the facial region, particularly the rostral part, relatively small. The cheek-teeth are essentially like those of *Apodemus*, but cusp 5 in m^1 and m^2 (Pl. XXVIII., Fig. 7) is reduced or obsolete; in m_1 and m_2 the outer row of tubercles is reduced to a low, laterally compressed ridge or cingulum. There are eight mammæ, of which two pairs are pectoral and two pairs inguinal.

Scharff (*Hist. Eur. Fauna*, 1899, 4) thinks that the "distribution indicates that the Harvest Mouse has most likely originated in the East, and has spread from there westward in recent geological times." No fossil remains of *Micromys* have so far been detected; but the existence of the species in Japan points to its being of ancient standing in the East.[2] Among Oriental mice, the arboreal genus *Vandeleuria* presents a close resemblance to *Micromys* in skull and teeth; the hinder part of the palate is, however, simpler and more normal in structure.

[1] See below, p. 565.

[2] We are informed by Oldfield Thomas that on examining reliable material recently he found that Blyth's *Mus erythrotis*, described from the Khasia Hills, Assam, is a species of *Micromys*.

THE HARVEST MOUSE.

MICROMYS MINUTUS, Pallas.

MICROMYS MINUTUS SORICINUS, Hermann.

1771. MUS MINUTUS, P. S. Pallas, *Reise*, 1, App., 454, described from the banks of the Volga, Russia; also *Nov. Spec. Glires*, 1778, 96, 345, pl. xxiv. B., etc.; as regards the typical form, of all subsequent writers.

1780. MUS SORICINUS, Hermann in Schreber, *Säugethiere*, iv., 661, pl. clxxxiii. B.; described from Strassburg, Germany; Gmelin.

1785. (MUS) TRITICEUS, Boddaert, *Elenchus Anim.*, i., 111; described from Hampshire, England.

1788. MUS SILVATICUS, var. *B.*, J. F. Gmelin, *Syst. Nat.*, 129; based on the "Harvest-Rat," Pennant, *Quad.*, ed. i., 302, n. 231.

1789. MUS MINIMUS, Gilbert White, *Nat. Hist. Selborne*, 43, 33, 34, 39; described from Selborne, Hampshire; *Mus minutus minimus*, Barrett-Hamilton, *Ann. and Mag. Nat. Hist.*, June 1900, 530; (*Apodemus*), Trouessart.

1792. MUS MESSORIUS, Kerr, *An. Kingdom*, 230; described from Hampshire; Shaw; Montagu; Pennant, *Brit. Zool.*, i., 121; Bingley; Turton; Fleming; Jenyns; Bell, ed. i.; Macgillivray; White, i., 58.

1794. MUS AVENARIUS, Wolf, *Versuche die Feldmaeusse zu vertilgen*, 16, 315; not seen, cited by Hermann, *Obs. Zool.*, 1804, 61.

1804. MUS PENDULINUS and MUS PARVULUS, Hermann, *Obs. Zool.*, 61; described from Strassburg, Germany.

1816. ? MUS ARVENSIS, Leach, *Syst. Cat. Spec. Indig. Mamm. and Birds, Brit. Mus.*, 7; a *nomen nudum* for "Harvest Rat" from Devonshire.

1822. MUS CAMPESTRIS, A. G. Desmarest, *Mammal.*, ii. 543; described from France; *Mus minutus campestris*, Barrett-Hamilton, *Ann. and Mag. Nat. Hist.*, June 1900, 529; described from Waremme, Liége, Belgium; (*Apodemus*) Trouessart.

1823. MUS MINUTUS, F. Boie, *Isis*, 970; described as very frequent in Schleswig and Holstein; *Mus messorius* stated to be probably a synonym of *M. minutus*, Pallas; A. Brants (1827); Oken, *Allg. Nat.*, vii. *ab.*, 2, 718.

1832. MUS MERIDIONALIS, Costa, *Fauna Reg. Nap.*, 13; described from near Naples, Italy; (*Apodemus*) Trouessart.

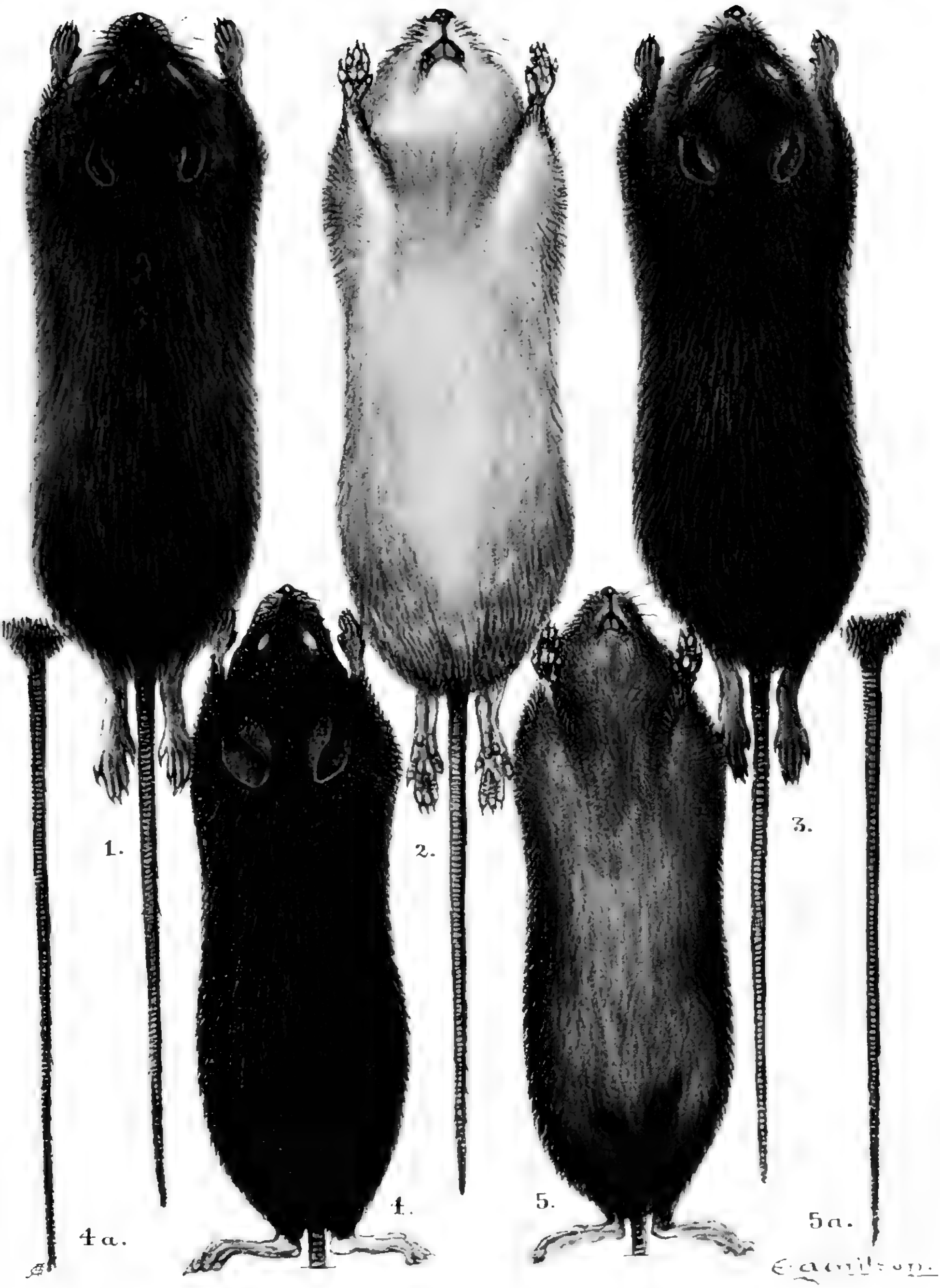
1841. MICROMYS AGILIS, J. F. A. Dehne, "*Micromys agilis, kleinmaus, ein neues Säugthier der Fauna von Dresden*," 1; described from Dresden, Germany; *Mus minutus agilis*, Barrett-Hamilton, *Ann. and Mag. Nat. Hist.*, June 1900, 529, from Brunswick, Germany; (*Apodemus*) Trouessart.

1841. MUS ORYZIVORUS, E. de Selys-Longchamps, *Atti d. seconda Riunione d. Sci. Italiani, Torino*, 1840, 247; described from ricefields in Lombardy.

1842. MUS PUMILUS, F. Cuvier, *Hist. Nat. de Mamm.*, *Tabl. Gen. et Méth.*, 4; described without name (in fasc. xxxii., October 1821) from vicinity of Paris, France.

1912. MICROMYS MINUTUS SORICINUS, G. S. Miller, *Catalogue*, 844.

The **synonymy** of the Harvest Mouse of western Europe, although long, is simple. In spite of the excellent description of *Mus minutus*



BRITISH *Muridæ* (SKINS);

(1, 2) *Epimys norvegicus*; (3) *E. norvegicus*, var. "*hibernicus*"; (4, 5) *Epimys rattus rattus*.

given by Pallas, most of the older writers hesitated to assert, though some like Shaw and Montagu suspected, the identity of the western Harvest Mouse with that of Russia and Siberia. Another cause of the multiplication of names is found in the great variability (dependent in part upon season, age, and sex, and in part, perhaps, upon the individual) of the animal itself. Boie in 1823 appears to have been the first to ascribe western specimens to *M. minutus;* his material came from Schleswig-Holstein, and he pointed out that the British *M. messorius*, Pennant, was probably a synonym. In 1827 A. Brants referred Dutch material to *M. minutus*, and although *M. messorius*, *soricinus*, and *pendulinus* figured in his book as distinct species (because specimens were lacking), he expressed his opinion as to their probable identity with *M. minutus* very clearly.

It cannot be pretended, however, that the material at our disposal is sufficient to enable us to form any very sound opinion as to the extent of the geographical variation of this species, nor even as to the status of the few sub-species at present recognised. Such material as exists is for the most part hardly mature, and there are few specimens, even of the British form, which can, from a skull point of view, be regarded as more than adolescent. Further collection may therefore very well cause certain of the names now relegated to the synonymy to be revived and used for the designation of sub-species in the future.

Terminology:—The Harvest Mouse is the *Mus minimus* of White (cited above); the "less long-tailed Field-Mouse" of Pennant (*Brit. Zool.*, 1768, ii., 498) and Berkenhout (1769). In all later works from Pennant (1776) to Millais (1905) it appears as the "Harvest Mouse," occasionally as the "Harvest Rat," so that there can be no serious question as to its correct designation, although the name is not now so appropriate as in the days of hand-reaping, when the species was much more frequently encountered at harvest-time.

Local names (non-Celtic):—*Harvest Mouse* generally; *Red Ranny* of Essex (Laver, *MS.*).

(Celtic):—Not usually distinguished. Welsh—*Llygoden yr yd* = "Corn-Mouse."

History:—The discovery of the Harvest Mouse in Britain appears to have been made independently by Gilbert White, in Hampshire, and Montagu, in Wiltshire. White, in his tenth letter to Pennant, dated 4th August 1767, alludes to a previous conversation on the subject ("which I mentioned to you in town"). Montagu (1767) has claimed (*Trans. Linn. Soc.*, vii., 274, 1803) priority for his discovery, but White's very accurate, and, for the date, complete account of the animal (Letter xii. to Pennant, 4th November 1767; xiii., 22nd January 1768; xv., 30th March 1768 ("Linnæus,

perhaps, would call the species *Mus minimus*"); and lx., 2nd September 1774, and the first edition of his *Nat. Hist. Selborne*, 1789) was undoubtedly first in the field of publication. Meanwhile, in 1771 and 1778, Pallas had described the Russian form, and his name takes precedence for the species as a whole. Pennant described the animal in the 1768 edition of his *British Zoology* (ii., 498) and acknowledged White as his informant, but in subsequent editions this acknowledgment did not appear, an omission probably due, as Alfred Newton informed us, to White's own modesty, for he himself corrected the proofs of Pennant's second edition. Since that date the mouse has been well known, although rarely seen by naturalists, except those of some of the southern and eastern counties, to whom and to Bingley, who wrote an excellent account of it in 1809, science is chiefly indebted for additional details of its economy.

Distribution:—The Harvest Mouse is a widely distributed species. In Europe its range extends from Scotland and Denmark southwards to the Pyrenees, and, in Italy, to the neighbourhood of Naples; eastwards from Britain it occurs throughout central Eurasia to Japan, where it lives in southern Hondo and on the islands of Shikoku, Kiushiu, and Tsu-shima. In eastern Asia its range extends southwards from the Transbaikal and Ussuri districts to the south of China (Sze-Chuan and Fokien).

It is not known from Norway (Collett); according to Lilljeborg and Winge it is also absent from Sweden, although Blasius and Clermont mention it as occurring there; but if really present in that country, it must have a very limited distribution. It occurs in Finland; in Denmark (Winge); and is one of the most common species in Schleswig-Holstein (Boie). It is absent from the whole of Iberia (Cabrera, Scharff), and probably from the extreme south of Italy.

In **Britain** it may, according to Millais, be regarded as generally but locally distributed south of Aberdeenshire, though in Scotland it is much scarcer than in England; according to Tomes (Bell, ed. ii., 288) it is common, but somewhat local, appearing in considerable numbers in certain fields or farms, but not occurring in others, although near. Originally found by White and Montagu in Hampshire and Wiltshire, this mouse has now been recorded from most English counties. In Hampshire it is universally distributed, and it occurs also, though less commonly, on Wight (Kelsall). In the Weald of Sussex it was very abundant about fifty years ago, but has now almost disappeared with the introduction of close-cutting reaping machines (Millais)—to which cause field-naturalists generally attribute the growing scarcity of the Harvest Mouse observed in other counties. It was at one time so numerous in the wealden districts of Kent and Sussex as to commit

considerable ravages in the wheat-stacks (A. Hussey, *Zoologist*, 1843, 349); in Kent it is stated to be still fairly common about Hever (Meade Waldo; also Collingwood in Millais). In Surrey, G. Dalgliesh (*Zoologist*, 1906, 188) records a pair taken in a corn-rick at Eashing, near Goldalming, and it was obtained in some number between Woking and Guildford by F. H. Salvin (Cocks). It occurs in all parts of Essex, according to Laver, and although he never met with more than a dozen in one rick, others told him of finding greater numbers; Laver (*in lit.*) says that the distribution in this county is extraordinary, since these mice are much more rare to the east of Colchester than to the west; it was frequent until about 1900. Several nests were taken in 1883, near Woodbridge, in Suffolk (E. C. Moor, *Zoologist*, 1884, 190), and Rope described it as not uncommon about Leiston (*Zoologist*, 1873, 3610). In Norfolk it was "somewhat local, but not uncommon" (Southwell, *Journ. cit.*, 1871, 2756); Southwell described it as still common in 1901; and Oxley Grabham (*in lit.*) "used to get considerable numbers from Haddiscoe." In Hertfordshire it is recorded by Bond (in Harting; see also *Vic. Co. Hist.*), although not found by Lydekker in the vicinity of Harpenden. In Cambridgeshire it was often seen by T. Bell's father, probably about 1784, and described to Bell as a third species of Field Mouse (Bell, *ipse*); from this county it is recorded by Jenyns (*Man. Brit. Vert.*, 31),[1] and also by Bartlett, who described it as occurring here, and commonly in Kent (*Zoologist*, 1843, 289); no recent records were known to Bonhote. From Nottinghamshire some mice and a nest were seen many years ago by W. Rigby of the Natural History Museum (J. W. Carr, *Vic. Co. Hist.*). In Northamptonshire it occurs, though not abundantly (Lord Lilford, *in lit.*); in Leicestershire and Rutland M. Browne describes it as rare. According to Tomes, it occurs in the southern and western, but not in the northern districts of Warwickshire[2]; it was obtained in Oxfordshire by Rolleston (A. H. Cocks). In Bedfordshire it was not uncommon, about 1830, at Benham, although not met with in recent times by Steele Elliot. Cocks has no knowledge of it in Bucks. In Worcestershire it was formerly more abundant in the valley of the Avon, according to Tomes, who often saw the nests. In Shropshire four or five nests were taken in August or September 1872, at Church Stretton, twelve miles from Shrewsbury (G. W. Murdoch, *Zoologist*, 1895, 447): Forrest states it to be very local in this county; he mentions a pair and nest in T. C. Eyton's collection from Weald Moors (70 71). Miss Pitt (*in lit.*) states that it

[1] Jenyns, *Obs. Nat. Hist.*, 73, says Harvest Mice "are common in Cambridgeshire."

[2] "About thirty years ago the late A. B. Herbert, Edinburgh, obtained a number from Warwickshire, and kept them for a year or two in a large cage made for their reception, where I have often enjoyed watching them exercising on the wheels and other contrivances for their amusement" (W. Evans, *MS.*).

is certainly not to be found anywhere near Bridgnorth. It is recorded from Staffordshire by Garner and Masefield, and Gloucestershire by Knapp and Mitchell (in Harting). From Devonshire it is recorded by Montagu, Rowe (who states it to be not common), Bellamy, Parfitt (in Millais), and Donovan (who had a specimen). In Cornwall one was caught by E. H. Rodd, 20th February (*Zoologist*, 1857, 5592); it was stated by Couch, i., 3, to be common, and was well known to C. W. Peach (*ibid.*, 5664); J. Clark (*Zoologist*, 1908, 416) describes it as very common locally about Penzance, Falmouth, and in the middle of the county, but as scarce or very local on the north coast. In Somerset, Charbonnier describes it as local, decidedly scarce in the winter, but fairly common a few miles from Yeovil; in the Bristol district it is rare and local. From North Wales, Forrest has no certain record, but he has received reports from Carnarvonshire and other localities (*North Wales*, 49); Phillips describes it as very rare indeed in Brecon, and Coward makes no mention of it in his list (*in lit.*) from Anglesey. It is sparingly present in Lancashire and Cheshire, according to T. A. Coward, who mentions (*Zoologist*, 1895, 175; 1896, 16) a nest from Southport in the Museum of Owens College, Manchester, 1864; in the former county many were found by the reapers near Garstang, in September 1843, and sometimes the nest and young were accidentally bound up in the sheaves without discovery or injury (M. Saul, *Zoologist*, 1843, 349); in the latter county it is now very rare, and has not been noticed in recent years (Coward). In the Lake District it is so rare that Macpherson knew of only two instances, namely, a nest taken many years ago at Blackwell, and a specimen captured at Silloth by J. H. Doeg in 1888; Macpherson (*Vic. Co. Hist.*) describes it as rare in Cumberland, but mentions specimens captured in isolated instances in the north. There is a vague record of it from Derbyshire (Jourdain). In Yorkshire it is very irregularly and thinly distributed (Clarke and Roebuck; copied by later writers); in Nidderdale, George Charlton said he saw it nesting in a cornfield—but no specimens were seen by authors; and Oxley Grabham (*in lit.*) writes that though he will not "go so far as to say it never has been taken in the county, the few records are so unsatisfactory that he holds it non-proven at present." J. T. Sewell (*in lit.*) claims to have found the nest near Helmsley, Yorkshire. It is recorded from a few localities in Northumberland and Durham (Mennell and Perkins, 1864, 171); it was taken by William Backhouse, at St John's, Weardale, 800 feet above the sea (*Trans. Tyneside Nat. Field Club*, iv., 94; for Durham, see also *Vic. Co. Hist.*).

The species thus seems to be much rarer in the north of England than in the south. It undoubtedly has occurred and probably still occurs in Scotland, but it must be very local and cannot be anywhere

numerous; as in the case of much of England, it would appear to have decreased or to be less often met with than formerly. Very sporadic records are all that could be collected for the Edinburgh district (1836-1905) by W. Evans, who however, himself found an unmistakable nest in August 1885, near Aberlady, East Lothian. Neither Harvie-Brown nor Millais (177) have met with the species in Scotland, and the former thinks that many records could be dispensed with. W. Evans states (*in lit.*) that he can obtain no fresh information from Scotland, and that he has quite failed to procure or see a specimen; he thinks the species may not really be indigenous, but occasionally establishes itself in a locality for a time. Prof. Duns found a nest near Duns, Berwickshire, before 1844; and Small (taxidermist, Edinburgh) informed W. Evans that about 1861 he received three, he believes from near the same town. Service (*Ann. Scott. Nat. Hist.*, 1896, 205) says that although he had seen and handled the mice and nests from corn-stalks on Rotchell Farm, near Maxwelltown, it has nowhere been seen or heard of in the Solway district for over twenty-five years. In Ayrshire it seems to have been common about 1855, and was seen by G. W. Murdoch (*op. cit.*). J. M. B. Taylor (*Ann. Scott. Nat. Hist.*, 1898, 112) mentions a nest found in 1895, at Kilbarchan, Renfrewshire, now in Paisley Museum, and states that he has seen other nests in the county. A doubtful specimen in the Andersonian Collection (Hunterian Museum) from the Clyde district is mentioned by Boyd Watt. In Perthshire, Millais believes it may occur in the Carse of Gowrie. It is mentioned in a list of animals from Alloa (*New Stat. Account*, *Clackmannanshire*, 9), in which also its size and weight are correctly noted; and the eastern distribution in Scotland of this comparatively southern form as compared with that of birds is discussed by Gray and Anderson (*Birds of Wigtownshire*, 4; E. R. Alston). One from Kincardineshire, caught in 1869, is recorded by R. Gray (E. R. Alston). It is not known in the Llanbryde district, according to Taylor. Macgillivray had two specimens, one sent from Aberdeenshire, the other from near Edinburgh, and he once found the nest in Fifeshire. Sim heard of one taken in 1889 at Kennay House, Banff, by Stewart Burnett (*Ann. Scott. Nat. Hist.*, 1898, 46); he also mentions one in Banff Museum, said to have been taken at Greenskairs, Gardenstown. This is in part confirmed by T. Edward (*Zoologist*, 1861, 7379), who received two from Wallas Gardiner, Greenskairs, Gamrie, Banffshire; Edward sent one of these, said to have been 4 inches long, including tail, and to have weighed $\frac{1}{8}$ ounce 13 grains, *i.e.* 4·38 grammes, or a little less than the weight recorded by Gilbert White (see p. 565) to the Banff Museum. W. Taylor (*Ann. Scott. Nat. Hist.*, 1897, 249) says there is no Harvest Mouse in Banff Museum, and he thinks Edward probably mistook young bright-

coloured Field Mice for Harvest Mice (see also W. Evans, *Ann. Scott. Nat. Hist.*, 1898, 47).[1]

According to E. R. Alston (*MS.*, in his copy of Bell), the Harvest Mouse is generally but locally distributed in the eastern lowland counties of Scotland, but it is absent from the west and north of Scotland.

The Harvest Mouse does not occur in **Ireland**, although it has been recorded thence in error on several occasions. Thus Bell's record (ed. ii., 291, *fide* Kinahan) has been shown by A. G. More[2] to be an error. A nest of young mice found in a thistle in a field of oats in Co. Donegal (S. A. Brenan, *Irish Nat.*, 1898, 125) may have been that of the Lesser Shrew (Scharff, *loc. cit.*). Thompson (iv., 1856, 15) also has a note from Shane's Castle Park, Co. Antrim, of a nest described as suspended between stalks of wheat, but this could not have been the nest of a Harvest Mouse.

Distribution in time, and origin:—The species is quite unknown as a fossil; its absence from Ireland, and its present absence from much of England and Scotland, together with its wide distribution in the East, indicate that it is an Eastern species which has arrived in western Europe only at a comparatively recent date.

Description:—The Harvest Mouse is characterised by its exceedingly small size, elongated and slender form, and by its bright coloration. The head is narrow, the snout short and blunt. The eyes are black, quite small, and less prominent than in the Field Mouse. The ears are relatively small, rounded and thick; they extend barely half-way to the eyes when laid forwards: in each the antitragus is developed as a triangular valve about 2 mm. high, capable of completely closing the meatus; this valve is clothed with a tuft of long hairs, nearly 5 mm. in length, and the general surface of the ear, both within and without, is clothed with shorter and finer hairs. In the **hands** the pads are arranged as in the Field Mouse, but the posterior two are relatively larger, closely approximated or even fusing together along the median line behind, and forming with the small thumb a single tubercular mass opposed to the balls of the fingers; in addition, a small free pad is present external to that at the base of the fifth finger (Winge). The **feet** are long and narrow (though relatively a little broader than in the Field Mouse); the soles are naked; the pads are like those of *A. sylvaticus* in number and arrangement, but the two posterior ones are relatively larger and of more elongated form, the sixth being

[1] Edward's description appears to leave little room for doubting that his specimens were really Harvest Mice; Taylor's suggestion does not seem probable, inasmuch as young Field Mice of the size indicated would be in the dull juvenal pelage (see the table at p. 515 above).

[2] In J. E. Harting, *Zoologist*, 1895, 420.

more than twice as long as wide. The **tail** is about equal to the head and body in length; it is thinly clothed with short hairs below, and still more sparsely above, the terminal portion of the upper surface being bare; there is no true pencil, though an inconspicuous tuft usually projects beyond the under-side of the tip; it has about 130 scaly rings which are more distinct below than above throughout, and on the dorsal surface of the prehensile terminal portion these rings are completely broken up. The tip of the tail for about three-quarters of an inch is distinctly prehensile, having the power of twisting on itself for about two turns, the upper portion being also capable of a half turn. The tip instinctively curls round and grasps anything that it touches, and thus affords a sense of security to its owner, but it cannot be used like a monkey's tail, to support the mouse's body or to swing by. It is thus slightly more differentiated than the tail of the Dormouse, which simply tends to twine round anything it may touch, and is far more advanced as a fifth hand, and in a slightly different manner, than the tail of a true mouse or rat, the function of which is balancing or sometimes delaying. The glands of Tyson are well developed (de l'Isle, 181).

Pelage:—The soft fur is comparatively thick and bristling. The hairs of the upper parts have slaty bases and bright-coloured tips, while those of the belly are white throughout for the most part, although some of them may have slaty bases also. The longer hairs of the back show but a slight tendency to assume the form of bristles. Winter specimens have the upper parts of an almost uniform reddish-brown **colour**, approaching but rather brighter than the "tawny" of Ridgway; although the tint on the sides of the neck and on the head is occasionally less bright than on the back, the difference is never great enough to produce any marked contrast. On the flanks and the outer surfaces of the legs the colour becomes gradually paler, fading towards ochraceous buff; the darker colour of the back is due in part to the black-tipped hairs with which it is inconspicuously sprinkled. The ears are lighter than the back, approximately matching the sides in colour. The under parts of the body and limbs are dull white. The line of demarcation along each side is regular and well defined, although (in a close view) the contrast between the lower flank colour and that of the belly is not a particularly striking one. The feet are of a pale yellowish-brown colour. The tail is obscurely bicoloured, the hairs of the dorsal surface being a light yellowish-brown, while those of the ventral surface are a little paler, the skin being light brown below and dusky above. According to Blasius, the winter colour is less pure red and more mixed with grey than is that of the summer pelage. Miller describes summer specimens from Germany (compared with winter skins from England and Switzerland) as having the upper parts noticeably darker and

duller than in winter, approaching the russet of Ridgway, but with a tinge of rufous ; the sides dull cinnamon, the under parts dull ochraceous buff, the median line having, however, especially about the chin and throat, traces of white in the form of ill-defined lines and blotches ; the line of demarcation inconspicuous, the feet and tail as in winter, but more thinly haired, and therefore more obscurely coloured. It is quite likely that were more mature material than that upon which these descriptions are based available, rather more vivid hues would be found to characterise both winter and summer coats than those indicated here.

Rope (*op. cit.*, 1884, 59) says that in the adults examined by him the bright sandy yellow or orange fawn of the upper side was purest and brightest towards the tail, on the hindquarters, and downwards towards the vent; this bright but delicate tint shaded off gradually into the yellowish or orange brown of the upper parts generally, which latter hue became brighter and lighter towards the white under-side. A large male lacked the orange tint altogether, the upper parts being nearly uniform brown, as in very old Brown Rats. Another male had the mid-dorsum dark red-brown, inclining to purple, owing to the unusual quantity of the long coarse dark hairs present.

Sexual differences :—According to Darwin, the female of *Mus minutus* is of a paler and dirtier tint than the male[1]; Rope (*Zoologist*, 1884, 59), however, fancies "the brilliant fawn tint" is most pronounced, as a rule, in females.

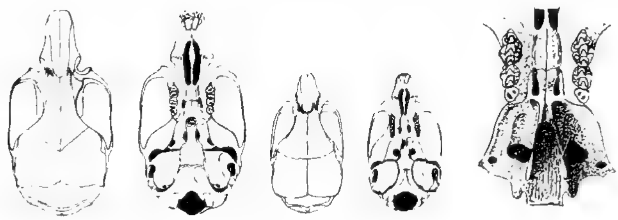
The **young** are duller coloured, more like House Mice in appearance than the adults. Harting (*Zoologist*, 1895, 421) observed some young, from Sussex, born in captivity; these, even when almost as large as the old ones, were not nearly so red. Indeed, until the beginning of December they resembled a House Mouse in colour. About that time, however, they began to change visibly, the hindquarters, from the root of the tail upwards, becoming rufous before any other portion of the body. Two young with Millais (174) began to assume the adult pelage in January.

Variation :—Tomes (in Bell, ii., 292) records the following variations—one from Warwickshire had the whole upper side of a dirty sulphur-yellow, the under parts as usual. One kept in confinement for a considerable time and fed on hemp seed became eventually "very much mottled with dark brown on the back"; it was then fed for several months exclusively on hemp-seed, but no further change took place. Perhaps speaking of the same case, Tomes mentions elsewhere (*Worcestershire*) one, which fed on hemp-seed, "changed from the usual yellow to a deep red chestnut colour."

Skull and teeth :—Apart from its small size, the delicate skull of

[1] *The Descent of Man*, ed. ii. (25th 1000, 1889), 534.

the Harvest Mouse is characterised by the great development of the cerebral, and the corresponding shortening of the facial regions. The smooth, ovate, evenly inflated brain-case nearly equals, and in Far Eastern sub-species occasionally exceeds, the zygomatic breadth in width. The parietal region is well vaulted; the edges of the short inter-orbital region are quite sharp, though not ridged. The anterior edge of the masseteric plate is straight, not curving forwards, and it scarcely projects beyond the front edge of the slender roof of the infra-orbital canal. The nasals fuse with each other at an early stage of growth; they are short and rather narrow; the processes of the premaxillæ supporting them in front are but weakly developed. The diastemata are short, the anterior palatal foramina are relatively about as in *A. flavicollis.* Notwithstanding the shortness of the rostrum, the palatal length is about as great relatively as in *A. sylvaticus;* this is due to the greater development of the posterior palatal shelf, which in this genus has a structure very similar to that of *Microtus* (*cf.* Fig. 89



1. 2. 3. 4. 5.

FIG. 89.—SKULLS OF *Apodemus* and *Micromys.*

Apodemus sylvaticus, (1) dorsal, (2) ventral view; *Micromys minutus*, (3) dorsal, (4) ventral view. (1-4 life size.) (5) Palate of *Micromys* (3 times life size).

with Fig 73D. above, p. 459). Posterior lateral bridges and fossæ, and a posterior median septum, the ventral surface of which is frequently slightly grooved, can all be distinguished just as in *Microtus*, but these parts, in correlation with the brachyodont teeth, are, of course, sculptured in lower relief in *Micromys*, and they are situated behind, instead of between, the tooth-rows. The inter-pterygoid space begins about 1 mm. behind the tooth-rows, and is narrower in front than behind. The basi-occipital is compressed slightly, its anterior width being less than its median length, and the median ridge and lateral furrows of its ventral surface are well defined. The bullæ are of large size and rounded form. The following *proportional* measurements (condylo-basal length = 100), obtained from a series of skulls representing nearly all known sub-species of *M. minutus*, may be compared instructively with those of *Apodemus* given in the tables at pp. 519 and 539 above:—(5) Cranial width, 51·7 to 57·8; (6) cranial depth, 30·9 to 36·6; (7) post-molar length, 48 to 50·9; (8) condyle to

bulla, 31·5 to 34·4; (9) and (10) nasal length and breadth, 29·2 to 36 and 8·6 to 11·5; (11) palatal length, 50·9 to 54·3; (12) diastemata, 22·1 to 25·2; (13) incisive foramina, length, 17·6 to 20·6. The dimensions not mentioned here are in substantial agreement with those of the Field Mice.

The mandible is much like that of the Field Mouse in form, differing, apart from its much smaller size, only in some slight details of the angular and coronoid processes, the former being a little more concave above, the latter a little more recurved. The **cheek-teeth** (Pl. XXVIII., Fig. 7) are described above under the genus.

Geographical variation:—In addition to *M. m. soricinus* and *minutus* (of which last no specimens have been seen), five or six other sub-species are at present recognised. Of these, *M. m. pratensis*, Ockshay (*Nov. Act. Phys.-Med. Acad. Caes. Leop. Car. Nat. Cur.*, xv., 2, 1831, 243, described from Western Hungary), ranges throughout Hungary into Rumania. In this form, as described by Miller, the posterior half of the body and the outer surfaces of the hind legs are as in *soricinus*, the head and the anterior half of the body are decidedly greyish, the white under parts receive a bluish tinge from the slaty hair-bases, and the tail is rather sharply bicoloured. In a series collected at Csehtelek, Eastern Hungary, during October and November 1913, by Fräulein von Wertheimstein, specimens with unworn or very slightly worn teeth (condylo-basal length from 15·6 to 16·5 mm.) have the coloration as in *pratensis*, the rufous tint so characteristic of similarly grown British Harvest Mice only appearing towards the rump; in a female with slightly worn teeth (head and body, 63; condylo-basal length, 16·9 mm.) the colour, save for slightly darker flanks, is nearly as bright and rufous as in specimens taken at Colchester in April; in a fully adult female with half-worn teeth (head and body, 71; condylo-basal length, 17·8 mm., B.M. No. 14.1.3.35) the colour is quite as red and bright on the head, back, and flanks as in the brightest English specimens; the hairs of the belly and chest are pure white to their bases, and on each side between the white belly and the rufous flanks there is a narrow belt of almost pure buff.

The remaining sub-species are Asiatic. *M. m. batarovi*, Kastchenko (*Ann. Mus. Zool. Acad. Imp. Sci., St Petersburg*, xv., 1910, 284), from the Transbaikal, is characterised by its short tail, measuring only from 60 to 70 per cent. of the length of the head and body; by its dark back, rufous towards the rump, and its ashy-white belly. *Mus minutus*, var. *kytmanovi*, Kastchenko (*op. cit.*), is described as an intermediate between typical *minutus* and *batarovi*. *M. m. ussuricus*, Barrett-Hamilton (*Ann. and Mag. Nat. Hist.*, April 1899, 344), described from Ussuri, Eastern Siberia, is a dark-backed form with the belly washed with dirty yellow, and no distinct line of demarcation. *M. m. pygmæus*,

Milne Edwards (*Rech. Mamm.*, 291, 1874), is a dark-coloured, rather long-tailed form inhabiting Southern China. *M. m. japonicus*, Thomas (*P.Z.S.*, 1905, 351, described from Shikoku), inhabiting Japan, is a dark-backed mouse with rufous rump and sharply contrasted white belly, the hairs of which have slaty bases; one old specimen, however, is more or less rufous over the whole of the upper surface (Thomas); the skull has an unusually large brain-case, and the cheek-teeth are decidedly larger than those of *ussuricus*.

It would appear that all forms of *M. minutus* have, at one stage of growth, dark backs, the rumps only being then rufous; that in the Western *soricinus* the change to the rufous coat of maturity is made quickly, and that some of the Eastern races, such as *pratensis* and *japonicus*, may acquire, at all events occasionally, such a rufous coat as old age advances.

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without hairs).	Hind foot (without claws).	Ear.
Average of 8 young in nest, fur just appearing (L. E. Adams)	27	21	8	..
MALES:—				
In rufous pelage:—				
SUSSEX (L. E. Adams), 3rd Sept. 1909 .	57	59	14	..
ESSEX, COLCHESTER (Dr H. Laver)—				
24th April 1903	55	55	14	8
Do.	57	55	14	9
Do.	58·5	54	14·5	9
NORFOLK, CONGHAM (Oxley Grabham)—				
26th Dec. 1898	64	61	15	9
Do.	65	58	14	8
NORFOLK, HADDISCOE (L. C. Farman)—				
24th Dec. 1898	58	52	14	9
Do.	59	58	14	8
Do.	59	56	15	8
1st Feb. 1899	59	57	15	8
FEMALES:—				
ESSEX, COLCHESTER—(Dr H. Laver)—				
24th April 1903	57	53	14·5	8·5
Do.	58	58	14	8
NORFOLK, HADDISCOE (L. C. Farman)—				
24th Dec. 1898	56	52	13	8

Remarks:—White (Letter xiii., 22nd Jan. 1768, to Pennant) found that his specimens from nose to tail were just $2\frac{1}{4}$ inches, and their tails just 2 inches long. Rope (*Zoologist*, 1884, 59) gives the average total length of seven adults as 4 inches $8\frac{1}{2}$ lines: the head and body averaging 2 inches $7\frac{1}{2}$ lines, the tail 2 inches 1 line.

Weight:—White (Letter xiii.) says: "Two of them, in a scale, weighed down just one copper halfpenny, which is about the third of

an ounce avoirdupois. . . . A full-grown *mus medius domesticus* [i.e. *sylvaticus*[1]], weighs, I find, one ounce lumping weight, which is more than six times as much." The weight thus indicated by White equals about 4·7 grammes. The weights recorded by other observers are:—Edward, Banff (see p. 559), $\frac{1}{8}$ ounce, 13 grains = 4·38 grammes; "an old one"[2] is said to have weighed 1 drachm, 5 grains = 2·09 grammes; another[3] "scarcely exceeds a drachm," or 1·77 grammes. The two last examples were probably immature nestlings, and the others can hardly have been fully mature, because Owen (*Anat. of Vertebrates*, iii., 143) gives the weight of a specimen which he dissected as 112 grains, or about 7·25 grammes. In this individual the brain weighed 6 grains, or nearly ·39 gramme; in a House Mouse weighing 327 grains, or nearly 21·2 grammes, the brain weighed no more.

Skull:—Condylo-basal length, 16 to 17·8; zygomatic breadth, 9 to 9·6; inter-orbital constriction, 3 to 3·2; brain-case, breadth, 8·6 to 9·6, depth at middle, 5·2 to 6·2; length of nasals, 5·4 to 6; of diastema, 3·9 to 4·6; of mandible, 9 to 10; of maxillary tooth-row, 2·6 to 3; of mandibular tooth-row, 2·6 to 2·8 mm.

Distinguishing characters:—The Harvest Mouse is readily distinguishable among British murines by its small size, bright reddish dorsal tints, and sharply contrasted white belly; its blunt short nose (somewhat recalling that of a young Bank Mouse); and by the characters of the ears, hands, feet and prehensile tail, as described above.

The Harvest Mouse presents us with many points of interest. Not only is it one of the prettiest and smallest of British mammals, but it is a highly specialised mammal, fitted by its structure for life amongst beds of strong grass, reeds, or corn, and living on a diet of seeds and insects. It is, consequently, a very acrobatic creature, light enough to poise itself on a head of corn, and a nimble climber amongst the stalks. It is a fine gymnast; at times it revolves[4] vertically, horizontally, or at an angle, balancing itself or helping a descent with its slightly prehensile tail[5]; but it is not as fast

[1] Or more probably in this case *A. f. wintoni;* for White gives the lengths of head and body and tail as $4\frac{1}{4}$ inches (108 mm.) each, the weight mentioned being nearly 29 grammes.

[2] Knapp, *Journal of a Naturalist*, 139; cited in *Zoologist*, 1843, 292.

[3] W. Hewett, *Zoologist*, 1843, 349.

[4] D. English, *Some Smaller British Mammals* (undated), 81.

[5] G. T. Rope, *op. cit.*, 1884, 58, has repeatedly seen one supporting the weight of its body on the tail for a second or so in trying to climb out of an upright glass jar, the fore paws merely balancing the animal's weight against the glass. Millais has seen them hang free by the tail, but it cannot swing or hang thus for any length of time.

and active as the House Mouse, nor a grand jumper like the Field Mouse, and hence it is more easily caught by hand. It is fond of frequenting tall, rank herbage growing by the sides of ditches,[1] especially such as have a little run of water through them.[2] Mr E. G. B. Meade-Waldo (*in lit.*) describes it as loving hedgerows fringed with brambles, grass, and weeds. In early spring he can always find it, before the herbage gets strong, running on certain banks in and out of holes, and along low branches; in August he sees it climbing about the grass and weeds. Unlike the Field Mouse, it is in the main diurnal, and in captivity it is aroused to activity by light. In summer it shelters itself during sleep, and rears its young, in a wonderful little round nest of plaited grass blades suspended so neatly amongst living plants as to have long excited the admiration of writers.

In winter, according to Gilbert White, it burrows deep in the ground, making there a warm nest of grass, in which it is supposed to hibernate.[3] But in corn-growing districts, where common, it seems to find all its wants more easily. Here it is satisfied by the corn-stacks,[4] where it shares its quarters with the House Mouse until threshing time, and exhibits no sign of torpidity. It prefers ricks of oats and wheat to those of barley,[5] and the lower parts of the stacks, or the rubbish on which they are built, to the upper parts[6]; after thrashing, it may remain on in the straw.[7] Sometimes large numbers,

[1] G. T. Rope, *Zoologist*, 1880, 57. [2] Dr H. Laver (*in lit.*).

[3] "All mice and voles sleep fitfully during the winter, hardly ever moving if the temperature falls below freezing-point, becoming active again in search of food when milder weather returns. To this rule the Harvest Mouse is no exception. Mr Thorburn caught one running in a hedgerow close to his house at Hascombe, Surrey, in December 1904" (Millais, ii., 182). Mr Meade-Waldo (*in lit.*) has never seen it in winter, except with the House Mouse in stacks.

[4] Either carried in the sheaves or finding its way there naturally. Though preferring corn-stacks it will also sometimes occupy hayricks (H. Laver, *MS.*), or straw (Millais).

[5] Perhaps because barley is too rich and indigestible, but English states that captives "are quite indifferent as to what kind of grain they eat"; and Patterson, East Norfolk, 1905, 315, mentions many found in the bottoms of barley-stacks.

[6] Gilbert White (Letter xiii.), however, mentions nearly a hundred under the thatch of an oatrick; see also H. Laver, *Field*, 14th April 1883, 499. The mice probably retire from the upper towards the lower parts as the dismantling of the rick progresses.

[7] H. Laver, *op. cit.*; G. T. Rope, *Zoologist*, 1884, 56, but whether it breeds in stacks or barns, as thought to do by Bell (ed. ii., 287), is uncertain.

but not usually so many as of the House Mouse, are killed when a rick is thrashed[1]; and White (Letter lx.) made the observation that on one occasion the dogs devoured the Harvest, but rejected the Common Mice; the cats, *vice versâ*. Blasius describes it as not rarely entering houses in autumn; this is not unlikely in the colder portions of Central Europe, although such a habit does not appear to have been observed in Britain.

The late Professor Schlegel[2] was so fortunate as to find the winter nests of the Harvest Mouse in a wide ditch near Leyden, Holland. These, composed of moss, were attached to and between the stems of several reeds, and resembled, though more fusiform, the nests of the Reed-warbler. Their height was from 6 to 12 inches, their breadth 3 to 4 inches; they hung about a foot over the water, without visible means of ingress, so that when entering a mouse had to find its way through the comparatively loose upper portion. In some cases the deserted nests of Aquatic Warblers had been adapted by provision of a cap of grass. The colony consisted of about fifty nests, and in summer these were replaced by the usual globular structures, of the average size of a man's fist, and with a small circular opening near the top.

The summer nests always contain a bed of soft shredded grass. They are placed in coarse, rank herbage; in low bushes in open country; but preferably near or on growing corn-stalks. The nest described by White (Letter xii.) "was found in a wheatfield, suspended in the head of a thistle"; that found by Macgillivray in Fifeshire was in the midst of a tuft of *Aira cæspitosa*, and about 9 inches from the ground; Blasius found nests in grass near a pond, and once saw "thousands" of the mice climbing and hanging on grass stalks over flooded ground; Schlegel found nests in *Rubus fruticosus*, *Rumex acetosa*, *Epilobium*, and in Purging Buckthorn[3] on sand-dunes in Holland. Other nests have been recorded in the boughs of a wild Clematis[4]; in long grass

[1] Landois, *Zool. Garten*, 1871, 163.

[2] *Notes from the Leyden Museum*, iii., 23-28, 1881; reprinted in *Zoologist*, 1881, 233-37.

[3] *Hippophae rhamnoides*.

[4] W. Hewett, *Zoologist*, 1843, 349.

near the hedges of stubbles in Kent and Sussex[1]; in tall sedges by the river Waveney at Gillingham, Norfolk; and in Marram-Grass on the sea-beach, almost within reach of the spray, at Kessingland, Norfolk[2]; in straggling Blackthorns beside a ditch (on 30th November); and in a plant of common Broom[3]; upon "laid" barley in Suffolk (several, almost all containing young)[4]; affixed to stems of *Centaurea nigra*[5]; 18 inches from the ground, supported by stems of grass and a few twigs of a hedge surrounding a cornfield, East Lothian[6]; and lastly, one on the ground amongst grass and clover.[7]

In this country, unlike the nests described by Schlegel (above), the summer nest, which is globular and of about the size of a cricket ball, has no regular aperture for entrance, though the place where the mice find their way in and out through the side or top is sometimes noticeable.[8] The body of the nest consists of leaves split into short lengths, which naturally contract, shrivel, and become confused together to form a bed. Mr D. English found 250 split lengths in a single nest, and calculated that at least 100 complete leaves had been utilised. When built in corn or reeds, the stalks are used as piles; the leaves growing from these piles are left attached to their stalks, although they are sometimes first split into narrow bands[9]; these leaves are interwoven so as to form the sides or foundation of the nest. Such nests, though no doubt compact enough when in their natural position, are difficult to handle when removed, for owing to their loose cohesion they easily lose their shape and swell in size. Nests built in less convenient or more precarious situations are stronger, and will suffer considerable violence without injury on removal; thus White's nest, from a thistle head, "was so compact and well filled, that it would roll across the table without being discomposed,

[1] A. Hussey, *loc. cit.*
[2] Crowfoot in Southwell, *Zoologist*, 1871, 2756.
[3] G. T. Rope, *Zoologist*, 1880, 57.
[4] E. C. Moor, *ibid.*, 1884, 190.
[5] Newstead, *Proc. Chester Soc. Nat. Sci.*, iv., 248.
[6] W. Evans.
[7] L. E. Adams (*in lit.*)
[8] They probably show entrance-holes when old; witness one with three apertures inhabited by eight nearly full-grown mice (W. Hewett, *Zoologist*, 1843, 349).
[9] Gloger in White's *Selborne*, by Bennett, 58, *note;* cited by Tomes in Bell, ed. ii., 290.

though it contained eight" young. The nests are probably put together rapidly, and their precarious situation amongst quickly growing herbage implies frequent change and reconstruction of domicile. Millais suggests that the nests are now more seldom found in standing corn than formerly; that, since it breeds several times during the season, there are several nests, the first among wild vegetation, another [or two] amongst corn, and a third or fourth amongst corn-ricks.[1]

Mr A. H. Waters enjoyed several opportunities for watching the Harvest Mice at work in a cornfield in Cambridgeshire. From his MS.[2] it would appear that the doe gathers the materials for the nest. She sits up at the base of the plants forming the chosen site, and holding a "leaf with her paws while biting the edge with her teeth, she tears off a long strip. Then holding one end of the strip with her teeth, she goes through a variety of movements so rapid that it is impossible to follow them, but the result is a tangle of the whole slender ribbon of leaf. . . . Next, after a run up and down the stems of the wheat or thistle, she proceeds to tug the tangle up to the summit. Sometimes. . . . she pushes it up, or carries it as well as she can in her teeth. Having got it up, she rests it where it will stop supported by the cornstalks or the branches and leaves of the thistle. . . . Now she splits the leaves of the wheat-stalk much as she did the detached leaf she selected for the foundation of her nest, but this time the strips are only half torn from the leaf. These strips she weaves in and out the tangled strip she carried up the stalk. The result is that the half-completed nest is securely fastened to three or four stalks and is free to wave in the wind" without risk. "Individual mice vary in their way of finishing the nest. Some do little more to it except making the bed inside the woven cradle. Others add more strips of leaf, and make a fairly compact structure. Some carry up grass stems and interlace them with the rest, and also take up leaves and

[1] For another description and figure of nest, see Landois, *Zool. Garten*, 1871, 162; he describes neighbouring grass-stalks as being bound to the nest to serve as ladders for the young.

[2] In chapter xx. of an unpublished MS., entitled *The World of Animal Thought*, by A. H. Waters, B.A. (quoted from an extract found among Barrett-Hamilton's papers; I have not been able to find out where the MS. itself reposes.—M. A. C. H.).

even feathers and scraps of wool. . . . I do not know whether it is universally the case that the buck assists the doe Harvest Mouse in the task of nest-making. But it does sometimes, and it is a pretty sight to see the two working together. Although the shyest of rodents, they do not seem to notice the observer if he remains perfectly still and carefully refrains from making any noise."

The nest of the Harvest Mouse is built for the special purpose of providing a safe and convenient nursery for the young. From White's day onwards much has been written about the young completely filling the nest, and consequent inability of the dam to sleep in it with her babies. White suggested that the dam had to open a different place in the periphery of the nest in order to suckle each of the young; while Johnston thought that they might even be suckled outside the nest. English says, however, that the babies get proportionately as much space as would young House Mice.

Mr Rope (*op. cit.*, 1884, 58) remarks on the superior architectural skill of this mouse, which can arrange its bedding in a square box in a round, compact nest resembling the spring and summer nurseries.

The Harvest Mouse appears to be, at least in summer, not less prolific than other murines, giving birth to several litters in each season.[1] The number in a litter appears to vary between five and nine, and gestation[2] is believed to last twenty-one days. The young are born naked and blind, and they attain the adult stature in six weeks.[3] Dr H. Laver has never met with the young in cornricks, "although they are said to breed there"; he considers the breeding season to be confined to the summer months.

[1] The following are the principal observations on the number of young in a litter:—Nine recorded by Pallas; in a nest in Brittany (E. D. Cumming); in Lancashire, M. Saul, *Zoologist*, 1843, 349; and by Gloger in Bell, ed. ii., 290. Eight by White (Letter xii.); Bingley, 267 (September 1804); in nest, Sussex, L. E. Adams (*in lit.*). Seven on three occasions, D. English (*op. cit.*, 83). Six to eight several times in Suffolk, Moor, *Zoologist*, 1884, 190. Six or seven naked and blind in nest, Macgillivray. Six in a nest lined with roots and fibres, not so compact as White's nest, but round as in his description, Jenyns, *Obs. Nat. Hist.*, 73, 29th July 1826. Five, Gloger in Bell, ed. ii., 290. G. W. Murdoch found two young but full-grown mice in a nest and three empty nests, in Shropshire in 1872 (*Zoologist*, 1895, 447).

[2] J. E. Harting, *Zoologist*, 1895, 421.

[3] J. H. Blasius, *Säugethiere Deutschlands*, 329.

Although some observers have found difficulty in inducing Harvest Mice to breed[1] or to rear their young[2] in captivity, others have met with more success. Mr Southwell[3] records two produced in captivity, but gives no details; de l'Isle's[4] captives bred twice; those kept by Mr Harting[5] bred and reared their young, and the latter became very tame.

Although they do not become as tame as Field Mice, a colony of Harvest Mice make clean and interesting pets, being easily fed and devoid of unpleasant odour. Dr H. Laver has found them peaceable in winter, but in spring the males fight and devour each other, and the young were always eaten after a few days.[6] Mr English finds a similar peaceable amiability combined with an unpleasant tendency to run amuck, sometimes resulting in the slaughter of most of the colony, and thus showing a very different temperament from that of the Field Mouse. Mr Tomes (in Bell, ed. ii.), describes it as gentle and not ready to bite, but requiring exercise. Mr Rope,[7] on the contrary, says that it bites savagely when handled, hanging on like a bulldog, and moving the jaws about while the teeth are still in the wound—in which it resembles the House Mouse and the Field Mouse.

The Harvest Mouse appears to live naturally on a mixed diet of seeds and insects. Mr Waters observed it pausing in its labour of nest-building to partake of a head of corn. As in the case of the Field Mouse, the range of dainties accepted in captivity is a wide one. Its insectivorous tastes were accidentally discovered by Bingley,[8] who saw his mouse spring at a passing bluebottle; Bingley caught the fly and made it buzz against the wires of the cage, whereupon "the mouse, though usually shy and timid, immediately came out of her hiding-place, and running to the spot, seized and devoured it." Afterwards, fed with insects whenever possible the mouse "always preferred them to every other kind of food" offered. Mr

[1] Eliza Brightwen, *op. cit.*, 137.
[2] Dr H. Laver, *op. cit.*
[3] *Zoologist*, 1871, 2756.
[4] *Ann. Sci. Nat. Zool.*, 1865, 181.
[5] *Field*, 2nd January 1875; *Zoologist*, 1895, 421; and in Lydekker, 183.
[6] Gurney, *Zoologist* 1884, 112, prevented this cannibalism by giving the mice a mutton-chop bone; he observed a large specimen begin to eat a smaller one's ear, the victim quiescent. See also Rope, *op. cit.*, 1884, 57; and Eliza Brightwen, *Wild Nature Won by Kindness*, 1896, 138.
[7] *Op. cit.*, 1884, 58.
[8] *British Quadrupeds*, 1809, 268.

HARVEST MOUSE. ($\frac{2}{3}$ natural size.)

E. Newman[1] also observed that bluebottles were a favourite food; according to Mr H. H. Crewe[2] another captive ate bluebottles and other flies, butterflies, moths, bees, wasps, lepidopterous larvæ, and especially cockroaches, of which it was known to eat fourteen in a night, seizing and worrying large ones; it also ate wheat, barley, oats, biscuit, cake, apple, nuts, bread and milk; but its favourite food was insects. Mr Rope's specimen ate broom-seed, wood-lice, and flies; describing its methods of catching the latter, Mr Rope[3] says that the mouse sits still until a fly buzzes near it, when, without apparent effort, it is "firmly grasped in the paws," and rapidly devoured, the wings and elytra being generally rejected. Mr Gurney's mice loved burrowing into fresh clayey moss; they were very fond of canary seed, and ate the twigs and early leaf-buds of hazel, as well as pieces of cooked meat off a mutton-chop bone.[4] Mrs Brightwen[5] mentions that her mice ate insects, canary seed, brown bread, and that they burrowed for growing corn. Millais[6] says they eat seed, shoots, and tender leaves; they enjoy all cereals, preferring wheat, but not caring for bread. In eating wheat, as described by Mr Rope,[7] the mouse sits up and holds the grain in a horizontal position between the fore paws, one at each end, then revolving the grain rapidly, it slices off the outer skin with its incisors until it obtains the clean white corn.

Like most murines the Harvest Mouse shows, at all events occasionally, a propensity to lay up a store of provisions; and those that remain in the field are said to form stores for the winter season, and congregate in small societies in the holes under some sheltered ditch bank.[8] In this connection one of Bingley's[9] observations may be quoted. His mouse made a nest of flannel and grass; on opening this nest about the latter end of October 1804, he "remarked that there were, among the grass and wool at the bottom, about forty grains of maize. These appeared to have been arranged with some care and regularity, and every grain had the corcule, or growing part, eaten out, the lobes only being left." Bingley soon afterwards put into the cage about a hundred additional grains of maize.

[1] *Zoologist*, 1867, 911. [2] *Op. cit.*, 1867, 554. [3] *Op. cit.*, 1884, 57.
[4] *Op. cit.*, 1884, 112. [5] *Op. cit.*, 138. [6] Millais, ii., 179. [7] *Op. cit.*, 1884, 56.
[8] Knapp, *Journal of a Naturalist*, 139. [9] *Op. cit.*, 269.

These were all in a short time carried away, and on a second examination, he found them "stored up in the manner of the former. But though the animal was well supplied with other food, and particularly with bread, which it seemed very fond of, and although it continued perfectly active through the whole winter, on examining its nest a third time, about the end of November," he observed "that the food in its repository was all consumed, except about half-a-dozen grains." Much of the animal's work of transporting the grass for its nest must have been done during the night.

Captives lap milk and water (Bingley, *op. cit.*, 268; Harting, *op. cit.;* and Millais, ii., 180).

The voice is said to be not pitched so high as that of the House Mouse, and to be rather "a harsh grating chirp than a squeak."[1] Mrs Brightwen[2] says that sometimes "in their great happiness they make a low, sweet chirping like a company of wrens conversing cheerily together."

Harvest Mice are very difficult to trap, and are usually caught by hand when leaving or entering their nests; this accounts for the dearth of really mature material noticed above. Their numbers, like those of "voles" and Field Mice, are subject to annual fluctuations, and in a "mouse year," at least on the Continent, they may form a considerable proportion of the total rodent population.[3] When present in large numbers, they are capable of causing much damage to crops despite their diminutive size; but their ravages are largely compensated by their insectivorous tastes.

As regards its longevity, Bingley's specimens lived for two and a quarter years in confinement, while Mrs Brightwen's[4] specimens began to die after two years' captivity; the longest lived one of ten kept at the Zoological Gardens remained there for thirty-three months.[5]

[1] G. T. Rope, *op. cit.*, 1884, 57. [2] *Op. cit.*, 138.

[3] Schlegel, *Zoologist*, 1881, 234; Blasius, *op. cit.*, 329; Landois, *op. cit.*, 163; and S. A. Poppe, *op. cit.*, *supra*.

[4] *Loc. cit.* [5] P. Chalmers Mitchell, *Proc. Zool. Soc.*, 1911, 448.

GENUS EPIMYS.

1867. RATTUS, L. Fitzinger, *Sitzungsb. kais. Akad. Wiss. Wien., math.-nat. Cl.*, lvi., Abt., 1, 63, included *rattus*, *decumanus*, *alexandrinus*, and others; antedated by RATTUS, Donovan, *Naturalist's Repository*, iii., pl. 73, page unnumbered, 1827, based on *R. donovani* from the Cape of Good Hope. (RATTUS, Frisch, *Das Natur-System vierfüss. Thiere, in Tabellen*, 7 Tab. gen., 1775; and RATTUS, Zimmermann, *Specimen Zool. Geog. Quad.*, 344-7, 1777, are not regarded as valid.)

1881. EPIMYS, E. L. Trouessart, *Bull. Soc. d'Études Sci. d'Angers*, x, 117 (sub-genus); based on *Mus rattus* of Linnæus (type); Miller, *Proc. Biol. Soc., (Washington)*, xxiii., 58, 19th April 1910 (genus); Thomas, *Ann. and Mag. Nat. Hist.*, December 1910, 604 (genus).

MUS of most authors.

Classification:—In 1910, Miller adopted Trouessart's name, *Epimys* (originally proposed as a sub-genus, of which *Mus rattus*, Linnæus, is the type), as the generic name of the House Rats, and restricted the Linnæan genus *Mus* to *Mus musculus*, Linnæus, and its allies. The genus *Epimys* was further defined by Thomas (cited above).

As now understood, *Epimys* is the largest genus of the sub-family, and includes a great number of Asiatic, Malayan, African, and Australian species. Many of these species, particularly in Africa, are of small size, and would be termed generally "mice" rather than "rats."

The genus is doubtless of Oriental **origin**, and in view of its wide natural distribution it must date from a comparatively remote epoch.

In **Europe** it may have been represented in the late Pleistocene (see p. 588); but if then present it subsequently died out. It is now represented here only by the two well-known species of true rat, *E. rattus* and *E. norvegicus*, both of which are comparatively recent immigrants from the East. *E. rattus* appears to have been introduced about the time of the Crusades, while its rival, *E. norvegicus*, did not appear here before the beginning of the eighteenth century. These two species owe their introduction to Europe, and their more recently acquired cosmopolitan distribution, to their parasitic habits, and their readiness to take advantage of the facilities for travel afforded by human commerce.

In this genus the external form and skull characters are essentially those of typical or but slightly specialised *Murinæ*.

The **skull** is strongly built, with well-marked supra-orbital ridges, which generally extend back to the outer corners of the inter-parietal; the front edge of the zygomatic plate is always convex; the posterior border of the palate is a simple shelf; the pterygoids are thin plates, and the pterygoid fossæ are deep and well defined. The **incisors** are much deeper than broad, and their wearing surfaces are normal and unnotched. The **cheek-teeth** (Pl. XXVIII., Figs. 8 and 9) are characterised by the complete suppression of cusps 7 and 3 in upper molars, which have consequently never more than three outer and two inner tubercles. The tubercles show a nearly transverse arrangement, and because of this and the more or less relatively large size of those forming the median row, the teeth, in the higher species, acquire something of a lophodont or laminated character—a feature which becomes better marked in certain more highly specialised Oriental relatives, e.g. *Nesokia*. $m\frac{1}{1}$ are never longer than the combined length of $m\frac{2}{2}$ and $\frac{3}{3}$; $m\frac{3}{3}$ show no tendency to disappear.

The **mammæ** vary from six to twelve or more; typically there appear to be three pectoral and three inguinal pairs, and, so far as is known, at least one pectoral pair is present in all species.

The **young**, born naked, soon acquire a soft, thick, and mole-like pelage, in which as a rule the dense underfur is grey; their colour is largely dependent upon this underfur; the upper parts are therefore greyer than in adults, and the belly is dark grey. The **moult** appears to take place usually in a gradual and inconspicuous manner, but in some Indian specimens of the *rattus* group the new fur of the rump is sharply separated from the old coat remaining on the head and shoulders.

The true rats may be regarded as the most successful of existing terrestrial mammals. Their activity, intelligence, prolificacy, and power of procuring and assimilating a great variety of foods are all of a very high order. The higher species are at home in all climates and under all conceivable conditions, except perhaps extreme cold. They accompany our ships to sea, and swarm in our houses. Although highly palatable, their cautious and cunning habits, their vigorous courage and high powers of defence and offence, enable them to attain a size which would be fatal to the continued existence

of the more sluggish-minded mice. They dig, swim, climb, and run with equal facility, and in turn assume with perfect indifference the rôle of rodent or carnivore. Their social system is so arranged as to avoid useless conflicts with members of their own species; and in times of hunger or scarcity they may unite to subdue game far above the powers of a single member of their race.

They are probably the greatest mammalian pests of the human race, and the account against them has been vastly increased by the discovery that they are the bearers of bubonic plague,[1] which they transfer to man by means of fleas, chiefly *Xenopsylla cheopsis* of N. C. Rothschild. Apart from plague, they cause enormous trouble, expense, and many deaths by being the primary host of *Trichinella spiralis* of Owen, which they transfer through pigs to men; by being carriers of equine influenza and of "foot and mouth" disease (see Shipley, "Rats and their Animal Parasites," *Journal of Economic Biology*, 1908, iii., pt. 3, 61-83). For a list of rat fleas, see N. C. Rothschild, *Bull. Entom. Research*, i., 1910, 89; for rodents and plague, see H. B. Wood, *Amer. Nat.*, 1910 (*Nature*, 4th August 1910, 149). W. C. Hossack (*Memoirs of the Indian Museum*, vol. i., No. 1, July 1907, 1-80, and plates i.-viii., 1907), discusses the rats of Calcutta, and states that *Nesokia bengalensis* is the rat concerned with plague there.

Their rapid growth and high fecundity cause both *norvegicus* and *rattus* to be suitable subjects for Mendelian research, the results of which, so far as they concern systematic questions, are dealt with below under the species.

All attempts at securing hybrids between these two species have failed hitherto. In ordinary circumstances the natural aversion of the species leads the stronger partner to bully or slay the weaker, unless great care is taken; but young individuals of the two species have been paired, and have lived for long periods harmoniously together (de l'Isle, Morgan, and others). The method of copulation differs in the two species, and this of course occasions difficulty also. Lataste (376-9), however, overcame both difficulties and engineered

[1] Plague:—*Field*, 31st December 1910, 1237 ("Country House"); *Nature*, 1911, 29th June, 592; 6th July, 18; 9th November, 56; 1912, 18th April, 177.

effective copulation (*i.e.* with the production of a vaginal bouchon), but the unions were infertile; his friend C. Mailles was also unsuccessful. Iwanoff (*Arch. des Sci. Biol.*, xii., 1907, 376; Marshall, 609) artificially inseminated a white mouse with spermatozoa of a white rat; two hybrid young, intermediate in size between mice and rats, were produced after a pregnancy of twenty-seven days.

Exceptional variation:—Specimens of rats and mice with the skin corrugated and devoid of hair have been occasionally reported; for instances and references, see *Proc. Zool. Soc.*, London, 1856, 38, and 1903, 336. Albinic or melanistic individuals are not uncommon. Tailless and other physically deformed rats are known, but such deformities appear usually to be the results of injuries.

Two species have to be described as **British**, viz., the Black or Ship Rat (*E. rattus*), and the Brown or Common Rat (*E. norvegicus*).

1. THE BLACK OR SHIP RAT.

EPIMYS RATTUS, Linnæus.

For **synonymy**, see below under sub-species.

Le Rat Noir of the French: *die Hausratte* of the Germans.

Terminology:—Rats (late Latin *ratus* and *rattus*, of uncertain origin (*N. E. Dict.*), but possibly derived from *rapere* (de l'Isle), *radere* (Skeat), or *rodere* (*Cent. Dict.*)) are not mentioned in the *Epinal Glossary* (about 700 A.D.), where the word *mus* is applied to shrews. They appear first about 1000 A.D., in Archbishop Ælfric's *Vocabulary* (ed. Wright-Wülcker, 1884), where *raturus* = "ræt." According to the *New English Dictionary* the word appears to have been adopted from the Latin first by the Teutonic languages in the form *ratton*, and later by the Romance tongues; the converse view, however, has been advanced by de l'Isle (see p. 582), and it seems probable that prior to the Crusades the name was applied to the House Mouse (see p. 579). In the Latin writings of Giraldus Cambrensis (1147-1223) rats are perhaps first clearly distinguished from mice; while in the *Vision of Piers Plowman* (1377), B. Prol., 146 and 200, "a route of ratones. . . . And smale mys with hem" are mentioned. Shakespeare, *Tempest*, Act i., sc. 2, 147, 1610, has: "Nor tackle, sayle, nor mast; the very rats instinctively have quit it"; and also *Measure for Measure*, Act i., sc. 2: "Rats that ravin down their proper bane."

Earlier British writers knew only one rat, viz., *rattus*, which Ray called "The Rat." In the earlier editions of Pennant (1766 and 1768), and in Berkenhout (1769), the Common Rat of the present day makes its appearance as the "Norway Rat," *rattus* being still the "Common Rat." Late in the eighteenth century (from Pennant, 1792 onwards), the two animals became known as the "Black" and "Brown" rats, and there has since been no change of usage. These names are not, however, very appropriate, since there are black varieties of the "Brown Rat," while a brown form of the "Black Rat" is very common or universal in several Eastern countries, and is well known as the "Alexandrine Rat." At the present time the most appropriate names for the two animals would seem to be the "Common Rat" and "Ship Rat," thus emphasising their chief British characteristics, and avoiding the ambiguities of terms based on differences of colour.

Local names:—

(Non-Celtic):—"Blue Rat" of Orkney and Channel Islands.

(Celtic):—Irish—*Franncach* = "Frenchman"; or *luch fhranncach* = "French-mouse"; *luchog mhor* = "big mouse" (as in Clare Island, Colgan, *Proc. R. I. Acad.*, xxxi., 4, 22, 1911); *galluch* = "foreign mouse" (C. M. Robertson); *raftan*, from English *ratten.*

Scottish Gaelic—*Radan* (C. H. Alston), or *rodan*, from the English "rat"; *radan dubh* = "black rat" (C. H. Alston).

Manx—*Roddan* = "rat."

Welsh—*Llygoden ffrengig* or *llygoden ffreinig* = "French-mouse"; *llygoden fawr* = "big mouse."

Cornish—*logosan vras* = "big mouse."

The name "French-mouse," although perhaps at first used in its literal meaning,[1] soon came to signify, at least in Ireland, merely "foreign mouse" (*cf.* Irish *eun francach* = "the French bird" = the turkey; and Welsh *crian ffreinig* = "French nut" = walnut); later the epithet was dropped, and both rat and turkey became known to the Irish simply as *francach.* Much useful and interesting information is collected in D. Comyns's *Irish Illustrations to Shakespeare*, 1894.

History and Distribution in Europe:—The Black Rat, using the name to cover the wild forms as well, was not known to the ancient Greeks and Romans. The occurrence of the word *ræt* in Archbishop Ælfric's *Vocabulary* (cited above) perhaps indicates that this animal was known to the English prior to 1000 A.D.; but since the word *rata* was the name of the House Mouse among the Provençals, it is possible that a similar signification may have attached to the Anglo-Saxon word. Some writers, as F. Cuvier (*Hist. Nat. Mammifères*) and Tomes (in Bell, ed. ii., 303), think that its establishment in Europe dates from

[1] But, as Mr Cocks points out, the adjective "French" has long, and until quite recently, been generally used for anything "foreign."

the sixteenth century only, and they cite Gesner as the first describer. Others suppose that the Black Rat arrived in Europe in the Middle Ages, and they rely on Albertus Magnus, who wrote in the middle of the thirteenth century, "*Est autem magnum quod nos ratum vocamus: et est in arboribus habitans, fuscum nigris in facie maculis* (*De Animalibus*, lib. xxii., 182); but this passage, as pointed out by de l'Isle, is a description of *Eliomys*, and may be cited as a proof that rats were unknown at Cologne, Germany, when it was written. They were certainly known in France in the early thirteenth century, since they are clearly indicated in the well-known ballads of Reynard (*Roman du Renart*, early thirteenth century; *Renart le nouvel*, late thirteenth century; and *Renart le contrefait*, early fourteenth century). Beyond the evidence of the legendary *Pied Piper of Hameln*,[1] no such early German record is known (but see under *Distribution in Time*, p. 588).

In England rats were considered nuisances in the thirteenth and fourteenth centuries (Rogers, i., 33). They were caught at Weston in 1297, and in Oxford on two occasions, in 1335 and 1363: in the former case a farthing apiece was paid for them, a circumstance which caused Rogers to think that, in the general practice that prevailed of using fur of all kinds, rat skins had a market value (*op. cit.*, 282). Arsenic as a poison was known (*op. cit.*, 33), and Chaucer has (in the *Pardonere's Tale*): "And forth he goth, no lenger wold he tary, Into the toun unto a Potecary, And praied him that he him wolde sell Som poison, that he might his ratouns quell." A femur was obtained from the midden of Rayleigh Castle, Essex, a stronghold occupied from the end of the eleventh to the beginning of the thirteenth century, but the whitish colour of the bone suggested that the specimen might be "somewhat more recent than most of the remains from the midden."[2]

The bones of "rats" found by J. P. Bartlett in Romano-British tumuli were in all probability remains of the Water Rat. References to rats occur in the *Master of Game* (218) and in Turberville (1575, 147), where they or mice are spoken of as food for falcons. Elizabeth's *Acte for p̃servacon of Grayne* set a price of one penny "for the heades of everie three Rattes or twelve myse."

In Ireland the Black Rat was probably numerous and well known from at least the twelfth century, for we have Giraldus Cambrensis's statement[3] (*Topographia Hibernica*, 1183-1186): *Est et aliud ibi* (*i.e.*

[1] According to this legend Hameln suffered a terrible plague of rats in 1259 or 1284. The piper attracted the rats with his music, and led them to destruction in the Weser. The citizens cheated him of his reward; whereupon the piper re-entered the city on 26th June, played another tune, and drew all the children, save a lame one, after him into the interior of the low hill called the Koppenberg. The records of the town were long dated from the latter tragic event.

[2] Hinton, *Essex Naturalist*, xvii., 17, 1912.

[3] See Millais, ii., 209, for other references to rats by Giraldus in Ireland and Wales.

in insula Aran in occidentali Connacticæ solo posita) notabile: quia cum per totam Hiberniam copiose nimis mures abundent, haec tamen insula mure caret. Mus enim nec nascitur nec vivit invectus. (There is another thing remarkable in this island—although *mures* swarm in vast numbers in other parts of Ireland, here not a single one is found. No *mus* is bred here, nor does it live if it be introduced.) The island, however, was probably not Aran, as suggested above, but Inishglora, or Caher, both in Co. Mayo, the sanctity of each of which was so great that no rat or mouse could live for even a few minutes on their shores; the earth of these islands drove rats and mice from any house on which it was sprinkled—see Browne, *Proc. Roy. Irish Acad.*, v., December 1898, 64; Westropp, *Proc. cit.*, xxxi., 2, 1911, 53.

The words *mus* and *mures* in the above passage are usually translated "mouse" and "mice," as in Bohn's edition of the *Topographia*, 64; but there is no evidence that Ireland, which has no "voles," ever suffered from superabundance of mice, and the word *mures*, to which Higden, writing his *Polychronichon* in the following (fourteenth) century (he died in 1363), added the word *nocentissimos* = "most harmful," was almost certainly applied to the Black Rat, *Epimys rattus*, which was at that time, as stated above, already quite well known in England and considered a nuisance. It probably made its way to Ireland quite as early as to England, since the Irish are known to have traded freely with England and Europe from at least the thirteenth century. Unfortunately, O'Flaherty (*Chorographical Description of West or H-Iar Connaught*, 1684) misinterpreted Giraldus, writing that "it (*i.e.* West Connaught) admits no rats to live anywhere except the isles of Aran, and the district of the west liberties of Galway," which is a reversed translation of Giraldus, but is important, as it accepts the meaning of *mures* as "rats."

About 1377, "rats or mice" are mentioned as doing damage in the Register of Archbishop Sweteman of Armagh (Lawlor, *Proc. Roy. Dublin Soc.*, xxiv., c. 8, 264, 1911).

In subsequent years rats were generally well known in Ireland, the common belief at the end of the sixteenth century being represented by four lines quoted by Fynes-Moryson (1559-1603; *op. cit. supra*, p. 326):—

> "Quatuor hybernos vexant animalia, turpes
> Corpora vermiculi, sorices per tecta rapaces.
> Carnivori vastantque lupi crudeliter agros
> Haec tria nequitia superas Romane sacerdos."
>
> For four vile beasts Ireland hath no fence:
> Their bodies lice, their houses rats possess;
> Most wicked priests govern their conscience,
> And ravening wolves do waste their fields no less.

The Irish practice of satirising or rhyming rats (and other animals) to death was frequently mentioned in the seventeenth century, starting, perhaps, with Scott's *Discoverie of Witchcraft* (1584). Thus Shakespeare made Rosalind say, in *As You Like It*, Act iii., sc. 2: "I was never so be-rhimed that I can remember since Pythagoras's time, when I was an Irish rat"; and the same idea is found in Ben Jonson's *Poetaster* (address to the reader; 1601): "Rhime them to death as they do Irish Rats"; in the same author's *Staple of News* (1625); in Randolph's *Jealous Lovers* (1646); Flecknoe's *Characters* (1665); and doubtless numerous other references could be given.

E. rattus is undoubtedly of Eastern origin. There is no clear evidence of its presence in Europe during the historic period prior to the Crusades (1095, 1147, and 1191); on the other hand, as shown above, the species was firmly established in western Europe shortly after those events, and there can be little doubt that it was imported by the navies of the Crusaders. De l'Isle's researches led him to believe that the Alexandrine[1] Rat was the parent source of the European Black Rat. He supposed that in the seventh century the "Alexandrine Rat" was still living a free life on the deserts of Arabia, because if it had been parasitic on man in the Near East at that time the torrent of Arab invasion would have brought it to Europe, whereas it did not appear in Europe until three or four centuries later. Subsequently it acquired parasitic habits, and it spread through Palestine, Egypt, and North Africa. From the Levant the ships of the Crusaders carried it to the northern shores of the Mediterranean, where it received a variety of names. The modern Greeks called it *ποντικος*, the Venetians *pantegana*, in each case in allusion to its arrival by sea; the Genoese named it *Topo* (a modification of *Talpa*), which is still used in Italy; the Romans called it *Sorco* (from *Sorex*); finally, in Provence, where the word *rata* was used as the name of the House Mouse, it received the name *rat*, and this Provençal name, as the animal spread into the cities of other Western peoples, followed it into all the languages of western Europe.

According to de l'Isle, the pioneer rats must have had brown backs and light bellies, and in Italy and Iberia this colour has been retained. Northwards of the Mediterranean region the brown pelage was changed, partly by climatic influences (as supposed by de l'Isle) and partly because of alimentary changes (according to Fatio), into a black one. This change cannot have taken longer than three centuries, or more than 900 generations of rats, to effect,[2] for Georgius Agricola (*De Animant. subterran.*, 1530, ed. 1657, 485) described the rat as "*Mus*

[1] De l'Isle meant the form called *E. r. frugivorus* below; see p. 595, footnote 1.

[2] If, as seems probable, the race arose as a Mendelian mutation (see under Geographical variation), the change was probably effected in a much shorter period.

major mole corporis mustelæ minimæ; pilis est subnigris; cauda procera, etc." In 1551, Gesner (*De Quadrupedibus*, 1, 829) described it as follows: "*colore subniger, vel fuscus, qui ventrem versus dilutior est,*" and in the rare copies in which his figure is coloured he depicts a rat of intense dusky hue.

Beyond the fact that it was later than in France or Britain, and that it must have been before the sixteenth century, nothing is known of the date of the introduction of this species to Germany. In Denmark, according to Winge, it did not appear until late mediæval times or even later. The first mention of it in Norway, according to Collett, was by P. Claussön, who stated, in 1599, that it was brought to that country by ships, and that it subsequently acquired there an extensive distribution, although only along the coast and in the market-towns; in 1613 the same writer added that it had been carried by shipping to the country north of Trondhjemfjord, but that it did not survive in that region long.

The Black Rat quickly multiplied in Europe and soon became a most formidable pest. War was waged against it with poison as early as the fourteenth century (see p. 580 above); a rat-trap is spoken of in the accounts of the churchwardens of St Michael's, Cornhill, London, for the year 1469; Shakespeare alluded to the rat-catcher[1] in 1592 (*Romeo and Juliet*, Act iii., sc. 1, 78); and doubtless most of the ordinary methods of destroying rats were familiar at an early date. So serious were the ravages of this species in some places, and so fruitless were the attempts made to exterminate it, that on various occasions appeals were made to the spiritual powers for protection. Thus Blasius mentions that at Nordhausen the people held a day of prayer on its account; while in the beginning of the fifteenth century the Bishop of Autun formally placed the animal under a curse.

Early in the eighteenth century the invasion of Europe by the Brown Rat began; and as this stronger and more fecund rival gained ground, the Black Rat waned in numbers, until at length it became extinct over a large part of its former domain in temperate Europe. This ousting of the Black Rat may have been in part due to a direct antipathy between the two species, and partly to the greater voracity of the Brown Rat, which perhaps tended to deprive the weaker species of provisions.

Robert Smith, rat-catcher to the Princess Amelia (*The Universal Directory for taking alive and destroying Rats, etc.*, 1768), describes the

[1] The same personage figured long before in *Piers Plowman*, A. v., 165 (1362) as "a ratoner." Pennant (*British Zoology*, ed. 1776, 101) states that "among other officers, his *British* majesty has a *rat-catcher*, distinguished by a particular dress, scarlet embroidered with yellow worsted, in which are figures of mice destroying wheat-sheaves."

Black Rat as in his day living in ceilings and wainscots, the "Norway Rats" in shores and sewers. He relates how he at one house caught the latter in the cellars, but in the upper part of the house nothing but Black Rats; he put all together in a great cage, intending to show them to his employer in the morning, but the Norway Rats promptly killed and devoured the Black Rats in his presence. Thomas Swaine, in *The Vermin Catcher*, 1783, states that in the fifteen counties in which he worked he never met Black Rats except in Bucks—a few in High Wycombe—and Middlesex; while in the city of London he found very few Norway Rats, but quantities of Black Rats. He thought the Norway Rats came from the shipping in the Port of London, and dispersed to country districts, where they were better able to master the Black Rats. In 1776 Pennant (*Brit. Zool.*, i., 101) noted that "the Norway rat has also greatly lessened their numbers, and in many places almost extirpated them"; and Goldsmith (*Nat. Hist.*, iv., 66, 1776) referred to it as "the Common Rat, as it was once called, but now common no longer."

Donovan (1820) speaks of it familiarly—and he observed the expulsion from a house in London of a numerous colony by Brown Rats. Frank Buckland quotes a passage showing that about 1850, certain of the older granaries of the Metropolis were still tenanted by this species, and in Bell's ed. ii. (303) it is said that they could still be found in old houses in London[1] and Edinburgh; but Macgillivray stated in 1838 that he had not seen a specimen captured in the latter city within the preceding fifteen years. About 1860 it "was not rare in Warwickshire, but we now doubt the possibility of obtaining a single example" (Bell, ed. ii., 303). It is said to have recently existed in Westmoreland in small numbers about fell-side farms (J. Goodchild, *Lakeland*, 80, 1883), and it was reported from parts of Cheshire as still not uncommon in 1890 (Coward and Oldham). No doubt many whose memories went back to the second quarter of the nineteenth century could recall unexterminated colonies of Black Rats; but the identification cannot always be trusted, for in many cases there has been confusion with *hibernicus*, the black race of the Brown Rat. For an account of these various records, see Harting (*Field*, 26th July 1879, 144; and *Essays on Sport and Nat. Hist.*, 156-170, 1883) and Millais (ii., 207).

As regards rural Scotland, it was described in 1813 as the only species met with in Forfar, and as being not rare in all the inland districts of Angusshire (Don, Appendix, 38; in Hendrick, *Agriculture of Forfar*). They were common in Aberdeenshire until about 1830. The Rev. G. Gordon sent specimens from Elgin, where, however, it was

[1] Mr Cocks has called our attention to the discovery of a colony in 1875 in a house on Cornhill, London; see also *Land and Water*, May 1874, 399.

much less common than the Brown Rat, to Macgillivray; and the latter, in 1838, said that "in Keith, which is at a greater distance from the coast, it is not very uncommon," and that it could still be procured in other inland towns and villages in Scotland. It was stated by Charles St John (*Wild Sports in the Highlands*, 76) to be extinct in Moray in 1850, although plentiful there twenty years before; the Rev. G. Gordon (*Zoologist*, 1844, 424) said that it occurred in this county in 1844, but he reported it to E. R. Alston as extinct in 1880. The small colony of black rats observed by Colonel Drummond-Hay in 1860, occupying a drain in the vicinity of Pitlochry (Bell, ed. ii., 303), may have been of the black race of *norvegicus* (*hibernicus*), or even black water-rats (*A. a. reta*). But Millais saw, in 1879, two undoubted Black Rats which had just been captured from a small colony discovered in a shop in Dunkeld. In 1651 it was stated that "a rat cannot live in Sutherland." "There is not a ratt in Sutherland . . . they die presently how soon they doe smell of the aire of the country. But they are in Catteynes, the next adjacent province, divyded onlie by a little strype or brook from Sutherland" (*Hist. Earldom of Sutherland*, 1813; J. A. Harvie-Browne, *in lit.*). In the Hebrides it is stated to be still extant on Benbecula (Harvie-Brown and Buckley, 36).

The Black Rat inhabited the Orkneys, where it was known as the Blue Rat (J. Wolley, *Zoologist*, 1849, 2344; J. M. B. Taylor, *Ann. Scott. Nat. Hist.*, 1900, 181). Barry (*Hist. of the Orkney Islands*, 1808, 320) says that it "was formerly numerous, and as destructive as the rest of the genus; but it has of late been confined to one or two of the islands, owing to the Brown Rat, which has almost entirely extirpated them through the rest of the country. In size and strength it is inferior to its adversary, but not in its disposition to plunder; and when once it has established itself in a place, there are no means known of expelling it." In 1813 Low (*Fauna Orcadensis*, 22) stated that it could still be found in South Ronaldshay, whence Barrett-Hamilton received one from T. E. Buckley in 1892 (*Ann. Scott. Nat. Hist.*, 1892, 267). W. Evans informs us that this colony was still in existence three years ago.

In the Shetlands, Millais believes that it is frequently killed at Lerwick. In 1904 he observed three dead specimens lying on a wharf in front of a store on Whalsey; these were Alexandrines (brown above, with grey bellies); Mr Nicholson, the owner of the store, told Millais that twenty years before these long-tailed rats were common, but they subsequently died out; in 1900 they were reintroduced by a German vessel, and they had since become very numerous about his storehouses and were a great pest.

The Black Rat is believed to occur in Scilly, but we have seen no specimens. Coward obtained all three sub-species of *rattus*,

together with *norvegicus*, upon Lundy. In the Channel Islands they were stated by Ansted (*Channel Islands*, ii., 201, ed. 2, 1862) to be "common in Alderney and Herm." They are known from Jersey, where they are pretty numerous, especially in the east; Guernsey, where they are also in fair number; and Sark, where they are abundant, there being no Brown Rats, and all landing being made by boats; this colony is of interest, inasmuch as it appears likely to be one of the last remnants of the original *rattus* stock. On Herm these rats are said to be stronger and more robust than on Sark, and to have longer hair on their backs (35 mm.). The "Blue Rat" of the Ecrehuo Rocks, a few miles to the north-east of Jersey, is *rattus* also; the species is becoming rare on all the islands with the exception of Sark (see R. H. Bunting, *Zoologist*, 1908, 464).

The species is now very rare in Ireland. Thompson (*Nat. Hist. Ireland*, v., 16, 1856) received one from Co. Cork in December 1842 (see Harvey, *Fauna of Cork*, 2), and he records it as then resident in various localities in Kerry, Armagh, Dublin, and Antrim; but Barrett-Hamilton (*MS.*), fearing confusion with *hibernicus*, doubted these latter records. In turn, Barrett-Hamilton stated this species to be not uncommon in the neighbourhood of his home at Kilmanock (*Zoologist*, 1887, 425; and 1888, 141); but no mention of these is to be found among his later manuscripts, and the old skins in his collection from Kilmanock are all referable to *hibernicus*. Barrington mentions a litter of Black Rats found at Levitson, Co. Kildare, in 1876. In 1911 Ussher discovered a colony in a corn-store at Dungarvon, Co. Waterford; he sent specimens to the Dublin Museum and to Barrett-Hamilton, from whom Hinton received one.

In Norfolk, Black Rats were considered rare and almost unknown by Southwell, but in 1895 Patterson discovered the species living in considerable numbers in certain parts of Yarmouth. This colony appears to be well established; it is chiefly composed of true *rattus*, the brown or wild-coloured forms being rare.

In 1905 Patterson (*Nature in Eastern Norfolk*) reported it as having never before been so numerous at Yarmouth. He says that in 1895 it forced itself into notice by an apparent increase, although strangely enough it seemed to flourish only in the south-western corner of the town, Regent Street then forming a boundary of its northern distribution. Patterson obtained over 100 examples within a few months, besides a great many from fishing-smacks. In the summer of 1896 Black Rats became troublesome in private houses, warehouses, and stores. At one grocer's store, where these rats had caused much trouble, the Brown Rat made its appearance, and the supply of Black Rats suddenly ceased as if they had fled, although they still swarmed in a neighbouring dwelling (*Zoologist*, 1901, 153). In 1906 and 1907

Patterson (*Zoologist*, and *Wild Life on a Norfolk Estuary*) reported that the rats were still apparently increasing in numbers and occupying fresh haunts; and he wrote that they were still abundant in 1910. Specimens taken by Patterson were sent by Southwell to Barrett-Hamilton from Yarmouth in 1896.

If the Brown Rat has displaced the Black Rat from a large part of Europe, the latter species is still unrivalled in the rôle of a mariner. As such it frequently makes a reappearance in ports and along coasts whence it has, as a landsman, long since vanished. Sometimes it comes ashore from wrecks. Thus T. Cornish (*Zoologist*, 1878, 388) notes that after the wreck of an Italian grain-ship, the *Espagnol*, in Acton Cove, Marazion, Cornwall, "the whole of the surrounding district was swarming with these little rats." The "English Black Rat" is also mentioned as "although rare in this district, not extinct," and Cornish recorded its occurrence in Cornwall in 1889 (*Zoologist*, 1889, 434 and 450). Again, a "breed" of black rats swam ashore at Seascale from the wreck of a foreign fruit-vessel in 1866, and became temporarily established (T. Lindsay, in *Lakeland*, 81); and another important description of a landing (on Man) of these foreign rats is given by Millais (ii., 213). A constant interchange of rats takes place between vessels lying in port and the land, but owing to the relatively small numbers of rats involved, such movements naturally attract attention less frequently. When at Marseru, Basutoland, about 1904, Mr Wroughton saw three specimens of *E. r. rattus* which came out alive from packing-cases imported by the hospital; these packages had come by sea from Europe to East London, and thence by rail, followed by over a month's trek.

Distribution and status:—*E. rattus* is naturally distributed throughout southern Asia. Semi-parasitic races (*E. r. frugivorus* and *r. alexandrinus*), retaining the wild coloration, have spread thence by way of Asia Minor and Arabia throughout Africa north of the Sahara and throughout the south of Europe. These on colonising temperate Europe have become completely parasitic, and have developed as a peculiar dusky race or sub-species, *E. r. rattus*. These parasitic races have been subsequently dispersed artificially though unwittingly throughout the world.

Within the last two centuries competition with the much larger and heavier Brown Rat (*E. norvegicus*) has almost completely eliminated the present species from the temperate countries of Europe, and from much of North America; here and there, however, in these regions colonies still manage to survive. In warmer countries more suited to its organisation, and where consequently it is not condemned to a purely parasitic existence, this species is well able to maintain its ground and is still the "common rat." At sea its lightness and superior

skill as a climber give it a great advantage over its adversary, and even in temperate latitudes it is still, and is likely to remain, the principal "ship rat."

Distribution in time, and origin:—Judging from its wild distribution and history, this species is of Oriental origin, and the group must be of considerable antiquity in the East. The only fossil remains known, however, are some of perhaps rather questionable age found in the Pleistocene of Europe. Pictet (*Mém. Soc. Phys. et Hist. Nat.*, 1846, xi., 90) described remains, from the gravels of Mattegnin, Geneva, apparently not distinguishable from this species. A lower jaw from the Pleistocene of Lombardy was described by Cornalia (*Mamm. foss. de Lomb.*, 1858, 38), who named it *Mus rattus fossilis.* To this form Woldrich (*Sitzb. kais. Akad. Wiss., Wien., math.-nat. Cl.*, 84, Abt. l., 250, 1881; and 88, Abt. l., 1025, 1883) referred jaws from the fissure deposits of Zuzlawitz, Bohemia, and his figures indicate a species similar to *E. rattus.* No fossil remains have been discovered in Britain. If present in Europe during the Pleistocene, the species must have died out, and it was subsequently reintroduced as described above. Many bones were found among the pile-dwellings of Mecklenburg; these may indicate the presence of the species in Germany before the 13th century (for references see Brandt-Woldrich, *Mém. Ac. Imp. Sc., St Petersb.*, 35, 67).

Description:—*E. rattus* is smaller, much lighter, and more delicately built than the Brown Rat; its tail is usually longer, never noticeably shorter, than the head and body.

The head is slender, with a pointed snout. The naked muzzle-pad is small and has a deep median groove, which is continuous with the lip-cleft. The eyes are large, but not particularly prominent. The ears are of a broad ovate or rounded form; they are of considerable length (half that of the head), projecting conspicuously from the fur and reaching or covering the eyes when laid forward. Their substance is thin and translucent; the inner and outer surfaces finely papillose and thinly clad with short hairs. They are practically destitute of meatal valves, the posterior border of the meatus having but a barely indicated ridge. The hands and feet are of moderate size, long and narrow, and they are provided with small, simple claws, which are longest in the feet; the dorsal surfaces of the hands and feet are clothed with short stiff hairs, but the palms and soles are naked. The skin of each digit is folded in scaly, annular corrugations, of which nine or ten are present on the lower surface of digit 3 in the hand and foot; on the upper surface, where the corrugation is finer and less conspicuous, the grooves and ridges are about twice as numerous; the hairs clothing the upper surface of the digits rise principally from the grooves between the corrugations. In each hand the thumb is reduced to a mere tubercle bearing a vestigial nail which does not extend to its edge; digit 5 is

THE BLACK OR SHIP RAT (*Epimys rattus*).

(1) LEFT EAR; (2) LEFT HAND; (3) LEFT FOOT. (Twice life size.)

slightly shorter than 2; digits 3 and 4 are of about equal length and a little longer than digit 2. There are five large and distinct pads, but there is no free supplementary pad external to that at the base of digit 5. In each foot the hallux reaches to the middle of the first joint of digit 2; digit 5 is slightly longer, reaching the end of the first joint of digit 4; digits 2, 3, and 4 are the longest of the toes, and nearly equal to each other, 3 being the longest. There are six plantar tubercles; of these the postero-internal is more than twice as long as broad, and it is wider in front than behind; the postero-external pad is well developed, and fully one-third of the size of that at the base of digit 5; a small free supplementary pad is situated externally but close to the pad at the base of digit 5, but no similar pad is normally present in connection with the pad at the base of digit 1. The skin between the pads is wrinkled; elsewhere it is smooth. The tail is long, its length usually exceeding that of the head and body; it tapers distally, is somewhat square in transverse section and distinctly annulated throughout, there being about nine of the scaly rings in a length of 10 mm. near the middle; it is clothed with short, stiff hairs both above and below, and these rise from the distal edges of the scales. At the root of the tail the hairs are sparsely distributed and very short, their length being equal to the width of one annulation and a half only; distally they gradually become more numerous and longer, their length being equal to the width of at least three annulations, and these latter they partially or completely conceal. Posteriorly the hairs project slightly beyond the tip of the tail, but they do not form a true pencil. The tail is relatively longer in the young than in the adult; it is composed of thirty-seven or thirty-eight vertebræ (de l'Isle), and has from 250 to 260 annulations in all. There are ten mammæ in the females, arranged in two pectoral and three inguinal pairs. Occasionally supernumerary mammæ are developed in the pectoral region; in some cases an additional teat may be present externally to either the right or the left anterior pectoral mamma; in others an additional pair may be developed just in front of or just behind the normal posterior pectoral pair.

Pelage:—The longer whiskers are longer than the head and ears; the lower two or three are white, the others dusky. In addition two or more long cilia usually rise from the supra-orbital region.

The general covering of the body consists of three kinds of hairs in all rats; but these kinds intergrade with each other perfectly. Very abundant and fine, unicoloured or annulated hairs, which attain a length of about 7·5 mm., constitute the underfur. The middle hairs, 10 to 13 mm. long, are usually annulated, and the general coloration of the animal is largely dependent upon the hue of their subterminal bands; many of these hairs are coarse and grooved, and impart a

somewhat harsh quality to the fur; on the back many of them are stiff, broad, flattened bristles, each with a distinct groove along its anterior or dorsal surface. In hot countries such hairs are in all rats frequently developed as spines. On the back, and particularly towards the rump, long black hairs, usually of from 20 to 25, but sometimes 30 or 40 mm. in length, occur; although these long hairs are a good deal more slender than many of the middle hairs, they also contribute towards producing a certain looseness and harshness in the appearance of the fur.

Colour:—The colour ranges from uniform dusky to brown, with a white or cream belly, and above it is usually darker along the dorsal line. Between the extremes every intermediate gradation may be found. These intermediates occur frequently in large towns or ports, where, owing to the cosmopolitan nature of the rat populations of such localities, much crossing probably takes place. In more open and remote districts the coloration conforms usually to one or more definite types, and intermediates are rare; for details, see below under Geographical variation.

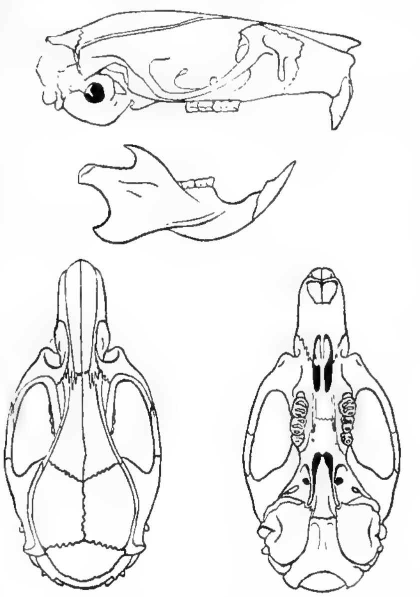


Fig. 90.—Skull and Mandible of *Epimys rattus* (life size). From Miller's *Catalogue of Mammals of Western Europe*; reproduced by the kind permission of the Trustees of the British Museum (Nat. Hist.).

Young:—The pelage of the young is relatively soft and full; all three kinds of hair can be distinguished in individuals with a head and body length of from 78 to 100 mm., but the bristles and long dorsal hairs in such specimens are relatively feeble and do not much exceed the underfur in length. In the "wild-coloured" races the coloration is generally like that of the adults, although the hue is duller and greyer. According to de l'Isle, the dusky (*r. rattus*) and the "wild-coloured" (*frugivorus*) races are distinguishable by colour ten days after birth.

The adult **skull** (Fig. 90) compared with that of *E. norvegicus* differs in its smaller size (condylo-basal length 38 to 45 mm., instead of 43·4, usually not less than 45, to 54·2 mm.) and lighter build. The brain-case is relatively slightly broader; the prominent supra-orbital ridges are continued backwards along the parietals, at a relatively low level, as outwardly curving (instead of approximately parallel) crests; the length

of a parietal, measured along a crest, is considerably less than, instead of about equal to, the greatest distance between the crests. The parietals are vaulted noticeably above the general dorsal profile, a feature emphasised by a slight flattening of the frontal and inter-parietal regions. The large inter-parietal extends relatively far backwards, and its boldly convex posterior border produces a characteristic backward deflection (from the plane of the mastoid processes) of the central part of the lambdoidal crest; as a consequence the occiput is vertical, the condyles are completely hidden in the dorsal view, and the occipito-nasal length amounts to from 105 to 106·5, instead of 102 to 104·5 per cent. of the condylo-basal length. The rostrum is relatively slender; its width amounting to from 17·6 to 20·3, instead of 19·5 to 22·3 per cent. of the condylo-basal length; the blade-like outgrowths of the premaxillæ beneath the nasals are rather large; the zygomatic arches as a whole are more slender; and the palatal length and the diastemata (in *E. r. rattus*, *alexandrinus* and *frugivorus*) are relatively a little shorter than in the Brown Rat. The auditory bullæ are relatively a little larger and more inflated than in *norvegicus*, and they compress to some extent the anterior part of the basi-occipital, the width of the latter bone in front being rather less instead of slightly more than half its median length.

As in all other mammals, growth produces many changes in the proportions of the skull, the facial region being the chief seat of post-natal growth. The following measurements from Hossack illustrate the process in the present species:—

Extreme length.	Cranial breadth.	Inter-orbital breadth.	Length of zygomatic plate.	Diastema.	Upper molar series.	Length of nasals.
	Percentages.					
Young, 28 mm.=100	50	19·6	8·9	26	25	33·9
Adult, 41·5 mm.=100	37·4	13·9	12·4	27·5	17·1	35·7

Apart from its smaller size the **mandible** does not differ importantly from that of *norvegicus*.

The **cheek-teeth** (Plate XXVIII., Fig. 8) have the outer cusps slightly less reduced, and in the upper teeth, the median tubercles slightly less developed than in *norvegicus*. In m^1 cusp 1 is distinct and usually nearly as large as x; as a rule there is no trace at all of an anterior cingulum. In m^2 cusp 5 is still evident although partially fused with z; in one case Forsyth Major saw this cusp placed so far forwards that it blocked up the entrance to the transverse sulcus. In m^3 a minute trace of cusp 1 may be present occasionally, but 5 is completely lost. In m_1 cusp 6 is apparently a constant feature, but n is always more

vestigial and may be wholly absent; m_3 appears to be rather more simplified than in *norvegicus*, but the posterior lobe when quite unworn shows distinct traces of cusps 4 and *y*.

Exceptional variation:—Individuals with a white chest spot, sometimes of very large size, or a median stripe of white, are not infrequent in *E. r. rattus*, and have been observed at Yarmouth by Patterson; similarly, individuals with a dusky patch or stripe are often found among the light-bellied forms. From the experimental breeding of *norvegicus* performed by Crampe, Doncaster, and Mudge, it would appear that such patterns are the subjects of Mendelian inheritance independently of the colour. A white-spotted *r. rattus*, from Kongsberg, Norway, has been recorded by Collett. Rarely, an ochraceous patch is seen on the ventral surface just behind either the right or the left fore limb (B.M., Nos. 1.11.3.26, Brazil, *alexandrinus*; 8.9.12.2, British New Guinea, *rattus*; both males). In some forms, particularly in the young, a white spot is present on the forehead: on such a variation from the Punjab, *Mus brahminicus* of Lloyd (*Rec. Indian Mus.*, iii., 1909, 22) is based; Fatio (p. 199) describes, from the neighbourhood of Geneva, a colony of Black Rats in which, young and old alike, all were characterised for many consecutive years by the presence of a conspicuous white lock on the centre of the forehead. Albino specimens have been known from the time of Gesner (see Kolazy, *Verh. Zool.-bot. Ges.*, *Wien.*, 1871, 731, and below under *norvegicus*). According to Patterson (*Zoologist*, 1907, 69), a male from Yarmouth was of a very pale blue-white colour and had fiery red eyes; its creamy white tail was rather shorter than usual. As is the case with *norvegicus*, a hairless variety, due to disease, is known (T. E. Belcher, *Zoologist*, 1904, 72; and J. Woodward, *Field*, 19th August 1905, 378).

Bellermann[1] said that "very often six to eight lie together and entwine their tails as closely as if they were fused with each other. Such a nest is called a 'King Rat.'" Blasius (319), repeating this curious statement, apparently on his own authority, says that the tails *are* fused, and that as such individuals are incapable of moving freely in the search for food, they must be fed by their parents or by other rats; hence the name *Rattenkönig*.

Geographical variation:—This species is represented in the Oriental region by a great number of named forms, but the status of many of these is still far from being satisfactorily determined. Oldfield Thomas (*Proc. Zool. Soc.*, London, 1881, 533) arranged the Indian members of

[1] *Daseyn des Rattenköniges*, 1820. Oken, *Allgem. Naturgesch.*, 7, Abt. 2, 719. A belief in "King Rats," dating at least from Gesner (*De Quadr.*, i., 829), is widely spread in Germany and in the German idiom, "*ein Rattenkönig von Unwahrscheinlichkeiten*" = "a perfect maze of improbabilities" (see Muret-Sanders, *Encyclop. Wörterbuch*; J. and W. Grimm, *Deutsches Wörterbuch*, 1893). Schreber, long ago, dismissed this belief as "a mere and very badly contrived fable."

the group in three sub-groups or varieties; he used the name *alexandrinus* for all the Indian forms of *rattus*, and stated that the "typical form," characterised by its large size, long tail, and coloration (dark rufous grey above, white below), inhabited Kashmir and the whole north-western region of India.

A somewhat similar arrangement was later adopted by Bonhote (*Fascic. Malay.*, Zool., i., 32, 1903; and *Proc. Zool. Soc.*, London, 1910, 653), who recognised three sub-groups of Oriental *rattus* as follows:—

(1) The **jalorensis** sub-group, of which *E. jalorensis*, Bonhote, from Jalor, Perak, and Siam, is the type. These are hill-rats representing the *nitidus* group of Thomas and other authors, and they have the hairs of the under parts white to their bases, and a hind foot length of about 30 mm. The sub-group has a wide but discontinuous distribution in India and Malaya.

(2) The **rufescens** sub-group, of which *E. rufescens*, Gray, from Dharwar, is the type. These are tree-rats, and have the hairs of the under parts with white or yellowish tips, and slate-coloured bases, and a hind foot length of about 33 mm. This sub-group is found throughout the whole of continental India, except the north-western part, and in Ceylon. In some provinces and in Ceylon a variety with a pure white belly is found side by side with typical *rufescens*, but in Burma and Tenasserim the white-bellied form alone occurs (Wroughton, *J. Bombay N. H. Soc.*, 23, 474 and 715). From Simla, Bonhote has described *E. vicerex*, a member of the group with striking bicoloration of the tail and white feet.

(3) The **griseiventer** sub-group, of which *E. griseiventer*, Bonhote, from Perak, is the type. These are chiefly house-rats, and in them the ventral hairs are either entirely slate-coloured or else have fulvous tips, and the hind foot measures about 35 mm. This sub-group has a wide distribution throughout India, Ceylon, and the Malay peninsula and islands.

Hossack (*Mem. Indian Museum*, i., 1-80, 1907) studied the rats of Calcutta in connection with plague; his material led him to regard the distinctions between the races of *rattus* recognised by Bonhote as quite inconstant and sporadic, and he therefore denied that such characters have any systematic importance. Bonhote (*Proc. Zool. Soc.*, London, 1910, 653), in answer to Hossack, states that in the large towns, whence all Hossack's material came, no order or classification is possible, because the varieties have become hopelessly mixed and crossed, but that in the country districts the varieties are much better defined, and apparently breed true; "all these varieties of the long-tailed rat belong to one species, *Mus rattus*." Meanwhile Lloyd (*Rec. Indian Museum*, iii., 1-100, 1909) studied a very large number of rats from India and Burma; his work was a continuation of that

of Hossack, and was carried out from a biological and plague point of view; he likewise criticises the systematists, but in his paper many facts supporting the view that the "varieties" of *rattus* breed true in the country districts will be found; thus rats in large numbers were collected from sixty-nine villages in the Punjab, but white-bellied specimens were only found in three rather widely separated localities, two of them in the Amritsar district, and one in the Lahore district.

The Egyptian races of *rattus* have also been studied by Bonhote (*op. cit.*, 1910), who finds only two forms evident there, viz.:—

(1) *E. r. frugivorus*,[1] Rafinesque, with white under parts and light-coloured feet, the hind foot being usually 35 mm. long.

(2) *E. r. alexandrinus*, Geoffroy, with slate-grey under parts and dark feet, the hind foot being usually 33 mm. long.

Owing to the propinquity of forms, these races are in Egypt very much mixed up together, and in practice merely represent extremes of a varying series. Bonhote regards these two forms as the analogues of the Indian *rufescens* and *griseiventer* sub-groups; he finds by measurements that a third type, indistinguishable by colour, but with a hind foot of 29-30 mm., exists, and he suggests that this corresponds to the Indian *jalorensis* sub-group, but in Egypt no difference of habit is visible.

A recent examination of the material in the British Museum from all parts of the world other than the Oriental region, amounting to more than 200 specimens, showed that, adopting Bonhote's definitions, *frugivorus* could always be distinguished from *alexandrinus;* but some difficulty was found in separating the darker specimens of *alexandrinus* from the paler phases of *r. rattus*. Bonhote (1910) showed that when the hind foot measurements of a large number of individuals were plotted as curves, either for *frugivorus* or *alexandrinus* separately or for both races together, the curve in each case showed three apices, viz., at 35, 33, and 30 mm. In *frugivorus* the major apex for both sexes occurred at 35; in *alexandrinus* it occurred at 33 for males and at 35 for females; the minor apex at 30 was regarded as an indication of the latent presence of a representative of the Indian *jalorensis* group. The material in the British Museum similarly treated has given a similar result, save that for both sexes of *alexandrinus* the major apex occurs at 33 mm. Such facts appear to indicate, according to Bonhote, that the three forms are in each case mutations, indestructible and ready to develop whenever a suitable environment offers. The curve for *r. rattus* is, however, much more complex, since it shows for both sexes large apices at 34 and 36 and a smaller one at 38; for males minor apices occur at 30 and 32 mm.

[1] Bonhote uses Savi's name *tectorum* for this form; "*tectorum*" is, however, antedated by *Musculus frugivorus*, Rafinesque.

Bonhote (*Proc. Zool. Soc.*, London, 1912, 6) found on crossing *frugivorus* with *alexandrinus* that the former was apparently a simple Mendelian dominant to the latter; and while the heterozygous *frugivorus* gave a proportion of pure *alexandrinus*, the latter always bred true. By the mating of *frugivorus* with *alexandrinus* thirty "hybrids," all being in appearance typical white-bellied *frugivorus*, were produced. Five pairs of these hybrids were mated, and their progeny consisted of 17 (apparent) *frugivorus*, 5 *alexandrinus*, 7 fawn *frugivorus*, and 1 fawn *alexandrinus*—the Mendelian expectation being 18, 6, 6, 2 for these respective kinds. The fawn types are novelties, arising probably from the absence from them of black pigment.

The classic experiments of de l'Isle, made shortly after, and unfortunately in ignorance of, Mendel's great discovery, seem to indicate that the dusky race *r. rattus* behaves in turn similarly as a dominant to *frugivorus*[1]; his results are, however, complex, and not easy to disentangle, probably because both *rattus* and *frugivorus* include a large percentage of heterozygous individuals. The hybrids of *rattus* × *frugivorus* on being paired together gave a progeny of numerous black rats, fewer *frugivorus*, and, as in the case of the cross *frugivorus* by *alexandrinus*, two novel types, viz., one relatively abundant, with light-coloured back and dark belly, called by de l'Isle the "semi-alexandrine"[2]; the other, much rarer, with dark back and white belly. The "semi-alexandrines" bred true. Morgan's experiments (*American Nat.*, xliii., 182, 1909) confirm in part these results deduced from de l'Isle's records; he found that whichever way the cross was made the progeny of *frugivorus* × *rattus* were black; in the first generation he raised thirty-two black individuals, but they showed some variation in the degree of their blackness. On pairing these hybrids, Morgan obtained a litter of four black and one grey, the blacks varying in shade as in the first generation; although the number bred is too small to yield any precise result, it indicates so far as it goes that the two colours follow Mendel's law.

It may be suggested that both *alexandrinus* and *frugivorus* have contributed to the formation of the black race, *r. rattus*, which has arisen, perhaps on many distinct occasions, in response to the exigencies of a new environment, namely, that afforded by an exclusively parasitic life in temperate Europe. The fact that the curve of the hind foot measurements shows a greater number of apices than does the hind foot curve of either of the two "wild" races is explicable on the assumption of such a multiple origin; further, *rattus*

[1] Although de l'Isle throughout his paper calls his light-coloured rat *alexandrinus*, his description of it as having the ventral hairs white to their bases leaves no room for doubting that his specimens were of the *frugivorus* race as defined by Bonhote.

[2] De l'Isle's "semi-alexandrine" corresponds apparently to *E. r. alexandrinus* as defined here.

behaves certainly as a dominant to *frugivorus*, and is therefore in all probability dominant to *alexandrinus* as well; lastly, having regard to the present mixed condition of the two "wild" races in Egypt, it is probable that the first immigrants to western Europe from the Near East comprised representatives of both *frugivorus* and *alexandrinus*.

In this work three[1] sub-species are described as British, viz., *E. rattus rattus*, Linnæus; *E. rattus alexandrinus*, Geoffroy; and *E. rattus frugivorus*, Rafinesque:—

(1.) THE BLACK RAT.

Epimys rattus rattus, Linnæus.

1758. MUS RATTUS, Carolus Linnæus, *Syst. Nat.*, 10th ed., 61, and 12th ed., 83, 1766; described from Upsala, Sweden; of most subsequent authors.

1800. M[US] R[ATTUS] ALBUS, ATER, CINEREUS, and MACULATUS, J. M. Bechstein, *Pennant's Allgem. Uebersicht d. vierfüss. Thiere*, ii., 494 and 713.

1833. MUS TECTORUM, var. FULIGINOSUS, Bonaparte, *Iconogr. Fauna Ital.*, i., fasc. 3, pl. xxii., fig. 1 (name on plate only); described from Italy.

1842. MUS SUBCÆRULEUS, Lesson, *Nouv. Tabl. du Règne Anim.*, *Mamm.*, 138; described from Rochefort, Charente-Inférieure, France.

1867. RATTUS DOMESTICUS, with the races FUSCUS, VARIUS, FULVASTER, ALBUS, and ATER, L. Fitzinger, *Sitzungsber. kais. Akad. Wiss. Wien.*, *math-nat.* Cl., lvi., (1) 64; described from Austria, Hungary, and Germany.

1902. MUS ALEXANDRINO-RATTUS, V. Fatio, *Revue Suisse de Zool.*, x., 402; described from Ticino, Switzerland (see Mottaz, *Bull. Soc. Zool. de Genève*, i., 163, 1908).

1905. MUS RATTUS RATTUS, J. G. Millais, *Zoologist*, June, 204; *M.* (*Epimys*) *rattus*, Trouessart.

1905. MUS RATTUS ATER, J. G. Millais, *Zoologist*, June, 205; described from London, England; type a male, No. 5.7.28.1 of British Museum collection; *M.* (*Epimys*) *rattus ater*, Trouessart.

1908. EPIMYS RATTUS, Satunin, *Mitth. Kauk. Mus.*, Tiflis, iv. Lief. 1-2, 112.

1912. EPIMYS RATTUS RATTUS, G. S. Miller; *Catalogue*, 853.

The Black Rat has figured in books as *Glis* (Jonston, *Quadr.*, 114, 1657) and *Sorex* (Hoefnagel, *Archetypa*, 3, tab. iii., 1592). Gesner mentions it (*Quadr.*, 731, 1551) as "*Mus domesticus major, quem vulgo rattum vocant*"; it is "*Mus Major seu Sorex*" in Merrett (*Pinax*, 167,

[1] The decision to regard *E. r. frugivorus* as distinct from *alexandrinus* has been reached since the key on p. 377 was drawn up; clause A of the section dealing with *E. rattus* should read:—

(A) Upper side brownish.

(*a*) Ventral hairs white to bases (*E. rattus frugivorus*).

(*b*) Ventral hairs with slaty bases (*E. rattus alexandrinus*).

1667); "*Mus domesticus major, sive Rattus*, the Rat" in Ray (*Syn. Quadr.*, 217, 1683), Sibbald (*Scot.*, 12, 1684), and Pennant (*Brit. Zool.*, ed. ii., 97, 1768); "*Mus rattus domesticus*" of Klein (*Quadr. disp.*, 57, 1751); and "*Mus* (*Rattus*) *cauda longissima, obscure cinereus*," in Brisson (*Quadr.*, 168, n. 1, 1762) and Gronovius (*Zooph.*, 4, n. 18). "*Mus rattus*" of Albertus Magnus (*de Anim.*, lib. xxii., 182, *circa* 1250) has been shown by de l'Isle to have been a dormouse (*Eliomys quercinus*).

The **synonymy** is that of the species and typical sub-species. It is perhaps to be regretted that in this case we are forced to regard as the typical form something which is apparently no better than an undesired product of domestication.

The **history**, **origin**, and **status** of this sub-species have been discussed above under the species (see headings *History*, *Distribution*, and *Geographical variation*).

Distribution:—Primarily the whole of temperate western and central Europe, from Ireland eastwards, and from central France and northern Italy northwards to central Sweden. Throughout this region its numbers have greatly diminished since the introduction of *E. norvegicus*, and over great tracts it has become quite extinct.

In Norway the original stock survived recently only at Kongsberg, but it is now dying out or else is extinct there. Although formerly common it was probably never so numerous in that country as *norvegicus* subsequently became. As a reintroduction a colony has established itself in the Oslo Havn at Christiania, and from time to time the animal, as in other countries, makes a transitory appearance in the various seaports. All Norwegian specimens belong to the present sub-species. In Sweden it survives in decreasing numbers from Skåne northwards to the centre of the country. In Denmark, though practically ousted by the Brown Rat in the course of the nineteenth century, it is still found occasionally, possibly as a re-introduction, in Copenhagen (Winge).

In Germany it was abundant about 1835; Blasius describes it as keeping entire towns to itself, and then, as the Brown Rat advanced, its domain dwindled to districts, streets, and, finally, individual houses. Dead specimens could often then be seen in the gutters of Berlin, and about ten years earlier, in those of Rhineland towns. By 1857 the species had become rare, and by 1879 very rare (Meyer, *Nature*, 8th and 29th May 1879). In Münsterland it is said, however, to have occurred commonly in 1883, in places where only the Brown Rat was found before, and in Greitz it appeared to be increasing at the expense of that species (P. Magnus, *Sitz.-B. nat. Freunde, Berlin*, 1883, 47); but possibly there is confusion with *hibernicus* here.

In France and northern Italy it is now uncommon. Gadeau de

Kerville (p. 173) describes it as being still very common in the country districts of Normandy, but as rather rare in the towns and those localities in which the Brown Rat is abundant; probably many of the Norman Black Rats belong, however, to the "wild-coloured" sub-species. In Switzerland, according to Fatio, it survived in 1869 at Geneva, where the Brown Rat had scarcely then attained a footing; the present sub-species and the "wild-coloured" forms were there equally abundant.

In **Britain** it was formerly widely spread both on the mainland and the islands. It is still occasionally met with in old houses in remote districts, but probably the only remaining mainland colony of any size is that at Great Yarmouth, Norfolk, studied by Patterson; further details of this are given above under the species (History). Other colonies are found in the Channel Islands, notably on Sark; perhaps in Scilly; on Lundy; in the Orkneys, on South Ronaldshay; and perhaps in the Hebrides, on Benbecula.

In **Ireland** it is now extremely rare; the only colony of "native" Black Rats reported in quite recent times is that at Dungarvon, Co. Waterford, alluded to above under History of species.

This sub-species has been carried by shipping from Europe to all parts of the world. Its introduction to South and Central America dates from the sixteenth century; Pennant (citing Garcilasso de la Vega, 384. Ovalle, *Churchill's Coll.*, iii., 44) says this happened about the year 1544, in the time of Viceroy Blasco Nunnez. The date of its introduction to North America is uncertain, but it was well established in the British colonies there in the beginning of the eighteenth century. Since the arrival of *E. norvegicus* its numbers have decreased, and it is now rare in most parts of the United States and Canada; it is now found in scattered colonies mostly east of the Mississippi valley, and on certain islands along the coast on both sides of the Continent. In parts of Central and South America it has been more persistent and is still abundant (D. E. Lantz, 11). It has acquired a wide distribution in Africa and Australasia. As an introduction to Indian ports it has succeeded in returning to the probable home of its ancestors; its success as a colonist varies, however, in different localities, for while Liston estimated (1905) it to form about 30 per cent. of all the rats of Bombay, Hossack found it very rare in Calcutta.

Description:—The general **colour** is slaty, darker on the back, paler below. The dorsal fur is long, black, and silky, and often shows in certain lights a greenish metallic lustre; the underfur and long dorsal hairs have slaty bases and black tips; intermixed with them are more or less numerous whitish hairs and bristles. On the under parts the fur is short and of a uniform slaty or light leaden hue. There is sometimes a chest-spot or stripe of white; more rarely a white spot

may be present on the forehead, and there may be some white on the feet.

The **young** have the fur softer, and their backs are of a richer and more lustrous black than in the adults; these features are chiefly due to the feeble development or absence of the whitish bristles.

Geographical variation:—Specimens brought from Black Sea ports to London were described by Millais as a distinct sub-species, *E. r. ater;* this was said to differ from true *rattus* in its deeper and richer pelage, its glossy black back, which presented a curious green sheen in a bright light, white or grey hair-bases, and slightly longer tail. Similar specimens were recorded by Millais from the Black Sea ports, Crimea, and various parts of Africa, and he states this variety to be the only one met with in the Transvaal. Miller does not distinguish this form from *r. rattus.* We have examined the type, an old male, together with specimens in the British Museum from Deelfontein, and as a result are inclined to adopt Miller's view. Nevertheless, there is probably some foundation for Millais' sub-species, since *r. rattus* may have developed independently in various parts of Europe at various times from quite different "wild-coloured" invading stocks. It may be added that, like all its relatives, this sub-species shows a tendency to develop races adjusted to the needs of purely local conditions. It is difficult to see where true *rattus* now exists, except perhaps in such localities as Sark and the Orkneys (South Ronaldshay).[1]

(2.) The Alexandrine Rat.

Epimys rattus alexandrinus, Geoffroy.

1803. MUS ALEXANDRINUS, I. Geoffroy St Hilaire, *Cat. Mammif. du Mus. Nat. d'Hist. Nat.*, Paris, 192; *Descr. de l'Égypte, Hist. Nat.*, ii., 733, Atlas, pl. v., fig. 1, 1812; described from Alexandria, Egypt; Savi; in part of de Selys-Longchamps and Blasius.

1905. MUS RATTUS ALEXANDRINUS, J. L. Bonhote, *Proc. Zool. Soc.*, London, 1909, 794, and 1910, 654.

1910. MUS (EPIMYS) RATTUS ALEXANDRINUS, E. L. Trouessart, *Faune des Mammif. d'Europe*, 144 (in part).

1912. EPIMYS RATTUS ALEXANDRINUS, G. S. Miller, *Cat. Mamm. West Europe*, 854 (in part).

As suggested long ago by Savi (*Nuovo Giorn. de'Letterati*, Pisa, x., 74, 1825), in defining his *Mus tectorum*, the name *alexandrinus* should be restricted to the sub-species figured by Geoffroy in 1812 (*loc. cit., sup.*),

[1] "Black and Alexandrine Rats" were taken in 1890 on a Leith steamer; the wild-coloured forms are abundant on some Scotch coasting vessels (W. Eagle Clarke, *Scott. Nat.*, 1891, 36, and W. Evans, *Supplement*).

i.e., to the form with brown back and dusky belly; this course has been adopted recently by Bonhote.[1]

Distribution:—Described from Egypt, where it is a house rat, the present sub-species inhabits much of North Africa; eastwards it ranges throughout Arabia and Palestine to India, where to the south and east it seems to be represented or replaced by the typical dark-bellied form of *E. rufescens*. It occurs in the regions around the Caspian and Black Seas, and we are informed by Andersen that all the specimens he collected in Bulgaria were of this type. The great majority of the Iberian specimens before us, and some from southern France (Biarritz), belong to this form.

In central and northern Europe it is no doubt occasionally introduced, but it does not appear to succeed in establishing colonies of any importance. No specimens of either "wild-coloured" sub-species have ever been obtained in Norway; but in the port of Copenhagen "brown-backed" specimens have appeared recently (Winge).

In **Britain** it is frequently introduced from shipping, but many of the published records of its occurrence refer to the next sub-species; it is not always easy or possible, however, to determine from the descriptions given which of the two sub-species is in question. Coward obtained *E. r. alexandrinus* in company with the two other sub-species and *norvegicus* upon Lundy, and apparently those seen by Millais on Whalsey, Shetland (see p. 585), were also referable to the present form.

In recent times it has been dispersed by commerce throughout many parts of Africa south of the Sahara; many specimens from this region are in the National collection, and some of them are so dark that it is not always easy to distinguish them from *E. r. rattus*. From America we have seen only two specimens—one from the Orinoco, the other from Brazil (Minas).

Description:—*E. r. alexandrinus* is indistinguishable from *E. r. rattus*, or the next sub-species, except by its coloration. The upper parts vary in colour between some shade of yellowish-brown and light grey; along the middle of the back black hairs are present in variable abundance, and to them is due the appearance of dorsal darkening frequently seen. The hairs of the ventral surface have slaty or dusky bases; in some specimens the tips of these hairs are dusky also, so that the belly is as dark as the flanks, or even as the back; in others the ventral hair-tips are yellow, cream, or white in colour, the belly being then slightly lighter than the flanks in general colour. The line of demarcation along each flank is never sharply defined, and is frequently not apparent at all. The feet are brown above, with or without dusky markings.

[1] See also Anderson, *Zool. of Egypt* (Mamm.), 1902, 274, and Bate, *Proc. Zool. Soc.*, London, 1904, 346.

histories of very many others, which were formerly little known, have been fully elucidated, while, speaking generally, an immense increase in our knowledge on such important subjects as Migration, Distribution, Habits, Nidification, Plumages, has accrued: And lastly, a new and important branch of study has been instituted—namely, the recognition of the various Racial Forms or Subspecies exhibited by certain birds in the British Islands, on the Continent, and elsewhere.

A great advance has also been made towards a more satisfactory system of classification of the Aves—always a difficult subject—and this necessitates departures from the older views.

To bring this Standard Work thoroughly abreast of the most recent knowledge in all these departments is the object of the present work.

It should be remarked that while it is not intended to go fully into Synonomy, yet, where changes of nomenclature have been necessary in order to conform with the Law of Priority—the only method by which complete uniformity in nomenclature can ultimately be attained—the names used in the Fourth Edition of Yarrell's "British Birds" and in Saunders' "Manual," and the Trinomial Names of the British Racial Forms, and of those occurring in Britain as visitors from the Continent, will be quoted, as will also the Original Name under which the species was described.

In requesting Mr Eagle Clarke to undertake the duties of Editorship, the Publishers desire to make it known that they are acting under the advice of the late Mr Howard Saunders, who placed all his collected notes for a New Edition at Mr Eagle Clarke's disposal for this purpose. That Mr Eagle Clarke is eminently fitted for the work is well known to all who are interested in ornithological science. Through his investigations of the subject, and contributions to its literature, he has long been recognised as one of the foremost authorities on all that relates to British birds. He has studied our native birds in many portions of the British Islands, and has visited a number of bird-haunts in various parts of Europe in order to become acquainted in their Continental homes with the visitants that seek our shores.

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PART XIX.—September 1916 Price 2s. 6d. net.

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BY

GERALD E. H. BARRETT-HAMILTON

B.A. (CANTAB.), M.R.I.A., F.Z.S.

AND

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A NEW AND REVISED EDITION OF
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HISTORY OF BRITISH BIRDS

EDITED BY

WILLIAM EAGLE CLARKE, LL.D., F.R.S.E., F.L.S.

Keeper of the Natural History Department, The Royal Scottish Museum; Member of the British Association Committee on the Migration of Birds as Observed on the British and Irish Coasts; Corresponding Fellow of the American Ornithologists' Union; Correspondirender Mitglied des Ornithologischen Vereins in Wien; Membre Honoraire du Bureau Central Ornithologique Hongrois; Member of the British Ornithologists' Union, etc.

ILLUSTRATED BY ORIGINAL COLOURED PLATES OF EACH SPECIES SPECIALLY EXECUTED BY

MISS LILIAN MEDLAND

THE publication of Yarrell's "History of British Birds" was commenced in 1837 and completed in 1843. Its outstanding merits were at once recognised, and a Second Edition was called for in 1845, followed by a third in 1856.

From the issue of the Original Edition down to the present day, Yarrell's "History of British Birds" has generally and deservedly been regarded as the standard authority on British ornithology.

In the year 1871 a Fourth Edition was begun, under the masterly editorship of Professor Newton—the greatest British ornithologist of all time. Unfortunately Professor Newton's official engagements at the University of Cambridge only allowed him to complete the first two volumes; and in 1882 Mr Howard Saunders was selected to edit the remaining volumes, a task which he successfully accomplished to the entire satisfaction of ornithologists in 1885.

The many excellences of this last edition advanced the work more than ever in the public and in scientific favour. To its stimulating influence is to be mainly attributed the marvellous and unprecedented activity which has resulted in those extraordinary advances made in all branches of British ornithology during recent years—advances which have rendered it essential that a new work based upon this classical and comprehensive foundation should be issued.

During the period alluded to, a considerable number of new and interesting species have been added to our avifauna. The

[*Continued on Page 3 of Cover*

CONTENTS OF PART XIX.

The English local names have been revised in part by Mr W. W. Skeat, M.A. (assisted by the late Professor W. W. Skeat), and in part by Mr C. M. Drennan, M.A. Lond., late Scholar Emm. Coll. Camb.; the Celtic and Gaelic names by Dr E. S. Quiggin, M.A., Ph.D., Fellow and Lecturer in Modern Languages and Celtic of Gonville and Caius College, Cambridge; while a list of Scottish Gaelic names has been supplied by Mr C. H. Alston. Much information has been taken from Mr G. S. Miller's recently published "Catalogue of the Mammals of Western Europe," the use of the MS. and proofs of which before publication was kindly permitted by the Trustees of the British Museum of Natural History.

ILLUSTRATIONS

FULL-PAGE (*Black and White*).

FIGURES IN TEXT.

Status:—The status of this sub-species has been discussed above under the species. The *semi-alexandrines* which appeared in the course of de l'Isle's breeding experiments (see p. 595) seem to represent this form, which may have arisen in the first place as a Mendelian mutation. By most writers it is considered as a mere intermediate between true *rattus* and the next sub-species, and it is the principal foundation of the statement, commonly found in books, that all intermediate stages can be found between the two extremes. As already mentioned, we have found occasional difficulty in separating dark specimens from true *rattus*, but we have not experienced any in distinguishing *alexandrinus* from *frugivorus*.

(3.) The Tree or Roof Rat.

Epimys rattus frugivorus, Rafinesque.

1814. MUSCULUS FRUGIVORUS, C. S. Rafinesque-Schmaltz, *Precis des Découv. et Trav. Somiologiques*, 13; described from Sicily.

1825. MUS TECTORUM, G. Savi, *Nuovo Giorn. de' Letterati*, Pisa, x., 74; described from Pisa, Italy.

1827. MYOXUS SICULÆ, Lesson, *Man. de Micromamm.*, 274 (substitute for *Musculus frugivorus*, Rafinesque).

1839. MUS ALEXANDRINUS, E. de Selys-Longchamps, *Études de Micromamm.*, 54 (in part); Blasius (in part); de l'Isle.

1841. MUS SYLVESTRIS, Pictet, *Mém. Soc. Phys. et d'Hist. Nat., Génève*, ix., 153; described from near Geneva, Switzerland (the name an alternative for *leucogaster*, Pictet).

1841. MUS LEUCOGASTER, Pictet, *op. cit.*, 154.

1841. MUS NEMORALIS, E. de Selys-Longchamps, *Atti della seconda Riunione degli Scienziati Ital., Torino*, 1840, 247 (an accidental substitute for *sylvestris*, Pictet).

1845. MUS PICTETI, Schinz, *Synops. Mamm.*, ii., 142 (substitute for *leucogaster*, Pictet).

1905. MUS RATTUS ALEXANDRINUS, J. G. Millais, *Mamm. of Great Britain*, ii., 205 (in part); (sub-genus *Epimys*) Trouessart (in part).

1909. MUS RATTUS TECTORUM, J. L. Bonhote, *Proc. Zool. Soc.*, London, 1909, 794, and 1910, 652.

1912. EPIMYS RATTUS ALEXANDRINUS, G. S. Miller, *Cat. Mamm. West. Europe*, 854 (in part).

Synonymy:—The present form, differing widely in appearance from *E. r. rattus*, has naturally attracted far more attention than the other wild-coloured sub-species, *E. r. alexandrinus*. By most recent writers it has been confounded with *alexandrinus*, but, as shown above, the latter name must be restricted to the form which, having a dusky belly, has been regarded generally as a mere gradation between the present sub-species and typical *rattus*. Savi's well-known name,

tectorum, is clearly antedated by Rafinesque's *frugivorus*, and must therefore give place to the latter.

Local name:—*Topo tettajolo* in Tuscany.

Distribution and status:—*E. r. frugivorus* is the common rat of the Mediterranean region and North Africa. Northwards it ranges throughout Italy into southern Switzerland. In France it is known from the south (Var), and it occurs also in Brittany and Normandy (de l'Isle). In Iberia *alexandrinus* appears to be the prevalent form, but we have seen specimens of *frugivorus* from Jerez, Cadiz. It is found on most of the Mediterranean islands;[1] in Greece, Montenegro, and Asia Minor; and it also occurs on the island of Sokotra. On the more remote islands, at least, it breeds quite true to type, and in the warmer parts of its range it leads an outdoor life, often inhabiting and nesting in trees in situations remote from human dwellings; in these warmer districts it does not tend to be replaced by *norvegicus*.

In **Britain** it not infrequently makes an appearance in the ports. As authentic instances of this kind, may be cited one captured at Sunderland (*Field*, 26th Jan. 1889, 126; B.M., 89.1.28.1); another taken on board ship at Liverpool (B.M., 6.10.25.1); and a specimen with pale lemon belly found by Patterson at Yarmouth. A good many were obtained by Coward on Lundy, where the two other sub-species and *norvegicus* were also found.

It is often found on ships, and has been carried by them to all parts of the world; in the warmer countries it not infrequently succeeds in establishing itself as a colonist, resuming at the same time, in many cases, a free outdoor existence. The British Museum collection contains many examples of such "colonial" *frugivorus* collected in tropical South America, Madagascar, Australia, and Tasmania.

Description:—*E. r. frugivorus* agrees in all characters, save those of pelage and colour, with typical *rattus*. The fur is often remarkable for its length, density, and softness. The upper parts are light grey or brown, brightening sometimes to russet, and darkened along the middle line of the back to a greater or less extent by long black hairs. The under parts are pure white or pale yellow in colour, the ventral hairs being light-coloured to their roots; sometimes a patch of bright orange hue is present upon the throat or chest. The line of demarcation is always regular and sharply defined along each flank. The feet are usually white above, but they are sometimes washed with light yellowish-brown.

[1] Rafinesque (*loc. cit.*) describes the Sicilian animal as living on fruit and nesting in the trees; he adds that it is edible—a circumstance which caused Lesson to refer the animal, with some hesitation, to the genus *Myoxus*. In the Balearic Islands, Thomas (*Proc. Zool. Soc.*, London, 1901, i., 42) found it "living a wild natural life, away from the houses," and he thought it "probably perfectly indigenous in the islands."

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
SEXUALLY IMMATURE OF BOTH SEXES:—					
Epimys rattus rattus:—					
1. Yarmouth, Norfolk, male, 7th March 1896 (Barrett-Hamilton, from Patterson)	93	117	28	18	..
2. Waterford, Ireland, female, 2nd June 1889 (W. Eagle Clarke)	94	135	31·7	17·8	..
SEXUALLY MATURE MALES:—					
E. rattus rattus:—					
1. Sark, Channel Islands, 7th Sept. 1912 (B.M., 12.10.1.1)	195	220	36	24	..
2. Guernsey, Channel Islands	214	252	38	25·5	..
3. London, S.E. (W. Eagle Clarke)	173	198	34 [1]	25	..
4. Do. (Type of *M. r. ater*, Millais)	210	235	36	..	..
5. Rhum (on board ship), 3rd June 1913 (D. Anderson)	173	214	35	21	..
6. South Ronaldshay, Orkney, 13th November 1905 (W. Eagle Clarke, *Ann. Scott. Nat. Hist.*, 1906, 49)	179	204	34·5	24	149·5
7. Belfast, Ireland, 24th Sept. 1889 (R. L. Patterson, per W. Eagle Clarke)	165	188	35·6 [1]	23·4	..
8. Do. 13th Feb. 1894	180	197	35·6	23·4	194·1
9. Do. do.	176	206	37·3	26·7	204·8
10. Do. do.	188	224	38·6	25·9	215·3
E. rattus alexandrinus:—					
1. Leith (ship), 20th Aug. 1889 (W. Eagle Clarke)	206	229	38·1 [1]	25·4	..
2. Lundy Island, 31st Aug. 1907 (Coward, B.M., 7.12.19.2)	209	233	40	25·5	..
3. Egypt, largest measured by Bonhote	199	220	35	26	..
E. rattus frugivorus:—					
1. Leith (ship), 20th Aug. 1889 (W. Eagle Clarke)	170	206	38·1 [1]	25·4	..
2. Liverpool (ship), 24th May 1905 (B.M., 6.10.25.1)	228	230	37	..	..
3. Lundy Island, 1st Sept. 1907 (Coward, B.M., 7.12.19.4)	199	234	37	25	..
4. Egypt, largest measured by Bonhote	188	232	35·5	24	..
SEXUALLY MATURE FEMALES:—					
E. rattus rattus:—					
1. Yarmouth, Norfolk, 7th March 1896 (Barrett-Hamilton, ex Patterson)	148	171	31	21	..
2. Do. ? sex, Feb. 1896	143	192	..	..	..
3. Do. do. do.	178	213	..	..	..
4. Do. albino, 28th Jan. 1907 (Patterson, *Zoologist*, 69)	152	140	..	..	..
5. South Ronaldshay, Orkney, 19th Oct. 1905 (R. Godfrey, W. Eagle Clarke, *Ann. Scott. Nat. Hist.*, 1906, 49)	156	196	35	23	..
6. Do. (J. M. B. Taylor, *Journ. cit.*, 1900, 181)	191	..	..	..	207·3
7. Belfast, Ireland, 24th Sept. 1889 (R. L. Patterson per W. Eagle Clarke)	178	207	36 [1]	25·4	..
8. Do. do. 13th Feb. 1894	173	208	35	..	190·2
9. Do. do. do.	176	207	36·9	24·1	185·7
10. Do. do. do.	170	199	35·8	24	189·4
11. Do. do. do.	187	206	38·4	25·4	215·5
E. rattus alexandrinus:—					
1. Leith (ship), 20th Aug. 1889 (W. Eagle Clarke) [2]	183	236	38·1	26·7	..
2. Egypt, largest measured by Bonhote	195	208	35	26	..
E. rattus frugivorus:—					
1. Leith (ship), 20th Aug. 1889 (W. Eagle Clarke) [3]	178	213	35·6 [1]	25·4	..
2. Lundy Island, 31st Aug. 1907 (Coward, B.M., 7.12.19.6)	167	201	36	22	..
3. Do. do. (Coward, B.M., 7.12.19.3)	177	196 [4]	38	22	..
4. Do. 29th Aug. 1907 (Coward, B.M., 7.12.19.5)	198	227	36	24	..
5. Egypt, largest measured by Bonhote	190	232	36·5	24	..

1 With claws.

2 Under-surface said by Mr Eagle Clarke to be of same colour as the back.

3 Under-surface described in Mr Eagle Clarke's notes as creamy white.

4 Tip broken.

Remarks:—The following measurements from Hossack (*op. cit.*, 9) illustrate the changes of bodily proportions which transpire with growth:—

	Head and body.	Percentages of head and body length.		
		Tail.	Hind foot.	Ear.
E. rattus, juvenile	95 = 100	147·3	31·5	18·9
Do. do.	100 = 100	145	29	19
Do. do.	105 = 100	128·5	27·6	16·1
Do. adult	173 = 100	121	19·1	12·1

Weight:—Two captive male *alexandrinus* (or *frugivorus*) weighed 4 and 5 ounces, or 113·3 and 141·6 grammes respectively; a female *E. r. rattus* in captivity weighed 5·25 ounces, or 148·5 grammes (Millais, ii., 208). The weights recorded by Eagle Clarke vary between 139·4 and 215·5 grammes, but as will be seen from the above table these weights are not those of the largest individuals enumerated. It is, however, improbable that the weight ever much exceeds 300 grammes; full-grown specimens of *norvegicus* frequently weigh from 450 to over 500 grammes. This great difference fully explains the inability of *rattus* to withstand its rival.

Skull:—Condylo-basal length, 38 to 45; zygomatic breadth, 19·2 to 22; interorbital constriction, 5·8 to 6·4; occipital breadth, 15 to 17·2; depth of brain-case at middle, 10·8 to 12·6; length of nasals, 14 to 17; of diastema, 10·2 to 13; of mandible, 23·2 to 28; of maxillary tooth-row, 6·4 to 7·4; of mandibular tooth-row, 6·2 to 7·2.

Distinguishing characters:—All the sub-species of *E. rattus* are best distinguished from all forms of *norvegicus* by their lightness, elegant build, longer tails, and larger and much more delicate ears. The adult skull has larger bullæ, and presents well-marked distinctions in the parietal and interparietal regions, as described above.

Habits:—A general account of the habits of rats is given below under *E. norvegicus*. The Black Rat is essentially a climber,[1] and does not burrow under houses or infest drains like its rival; it shows no liking for water, which it perhaps only enters occasionally, as when danger presses. As compared with the Brown Rat, it is doubtless in the main a clean feeder—possibly evidence of its more salubrious station rather than of a nicer or daintier palate. Lataste (313) says that it is by no means mute. Observers differ as to its odour, for while de l'Isle (184) describes it as more odorous and fetid than *norvegicus*, Adams (MS.) states it to be without the offensive smell of the latter species.

According to Shipley,[2] this species does not breed before it has

[1] Hossack describes it as scampering upside down along the cage wires.

[2] *Journ. Econ. Biol.*, iii., 1908, 62.

attained a weight of at least 70 grammes. De l'Isle found it sexually mature before the age of three months, apparently full grown at four months, and that it did not live for more than two years, the old ones being infertile. Thirteen kept at the Zoological Gardens had an average longevity of seventeen months, the maximum being forty-one months.[1]

De l'Isle found the period of gestation to be between twenty-three and twenty-four days; Bonhote (*in lit.*) finds it shorter—from twenty to twenty-one days. From two to four litters are born annually, the number of young per litter ranging between four and eleven. During the hot months in India,[2] and probably in other countries also, the percentage of young present in the whole rat population increases.

The young are born naked, except for the whiskers, which are visible with a lens (de l'Isle, 230), and pink; their eyes and ears closed; the length of the head and body at birth is about 50 mm., while the tail measures only about a third of that amount. At the fifth day the whiskers reach to the eyes, a feeble down covers the body, and the tail is about half as long as the head and body. On the tenth day the pelage shows colour, the whiskers reach to the ears, the latter still being only little "tags" (Hossack). On the eleventh day the eyes are open but feeble; the young are now clumsy, able to walk but not to run. At the eighteenth day the molars are still hidden within the gums, and the aliment is almost entirely milk. At the twentieth day the rat can run well; it is outwardly completely developed except in size and tail. At the twenty-first day the front pairs of molars are cut, but three-fourths of the aliment is still milk; on the twenty-fourth day eight molars are in place, and milk forms only about one-fourth of the aliment, the young being weaned about the twenty-seventh day. By the fortieth day all the cheek-teeth are cut (de l'Isle).

2. THE BROWN OR COMMON RAT.

EPIMYS NORVEGICUS, Berkenhout.

1769. MUS NORVEGICUS, J. Berkenhout, *Outlines Nat. Hist. Great Britain and Ireland*, i., 5, described from Great Britain; 1777, Erxleben, *Syst. Regn. Animal.*, i., 381, gen. 37, described from Norway; Rehn, *Proc. Biol. Soc.*, Washington, xiii., 167, 31st Oct. 1900; Collett, *Norges Pattedyr*, 180, 1911.

1772. MUS AQUATICUS, J. Rutty, *Nat. Hist. of the County of Dublin*, i., 281; a confusion with *Arvicola amphibius*.

1777. RATTUS MIGRANS, Zimmermann, *Spec. Zool. Geogr. Quad.*, 345.

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[1] P. Chalmers Mitchell, *Proc. Zool. Soc.*, London, 1911, 448.

[2] *Etiology and Epidemiology of Plague* (Calcutta, 1908), 9.

1778. MUS DECUMANUS, P. S. Pallas, *Nov. Spec. Quad. e. Glir.*, 91; described from Europe; of Gmelin and most subsequent authors.

1779. M(US) SURMOLOTTUS, Severinus, *Tentamen Zool. Hungaricæ*, 73; described from Central Europe.

1800. M(US) D(ECUMANUS) HYBRIDES, J. M. Bechstein, *Pennant's Allgem. Uebersicht d. vierfüss. Thiere*, ii., 713; described on p. 497; based upon a melanistic specimen for Waltershausen, Germany.

1800. MUS AMPHIBIUS, J. Landt, *Forsög til en Beskrivelse over Færöerne*, Kjöbenhavn, p. 238; Færoes.

1808. MUS FOSSOR, Walker, *Essays*, 497.

1816. MUS CASPIUS, Oken., *Lehrb. d. Naturgesch.*, iii., pt. 2, 895; an alternative for *decumanus*.

1837. MUS HIBERNICUS, W. Thompson, *Proc. Zool. Soc.*, London, 52; based upon melanistic specimens from Rathfriland, Co. Down, Ireland, *Nat. Hist. Ireland*, iv., 16, 1856.

1908. EPIMYS NORWEGICUS, Satunin, *Mitth. Kauk. Mus.*, Tiflis, iv., Lief. 1-2, 111.

1910. MUS (EPIMYS) NORVEGICUS and M. (E.) NORVEGICUS HIBERNICUS, E. L. Trouessart, *Faune Mamm. d'Europe*, 142.

1912. EPIMYS NORVEGICUS, G. S. Miller, *Cat. Mamm. West. Europe*, 858.

Le surmulot of the French (*rat* being the generic name); *die Wanderratte* of the Germans.

The **synonymy** given above relates to the Brown or Common Rat in Europe. Specimens from other parts of the world, *e.g.*, India, have received further names, but these do not require consideration in the present work. Up to 1900 practically all writers used Pallas's name *decumanus* (1778) for this species; but Rehn (*loc. cit. supra*) pointed out that Erxleben's *norvegicus* (1777) must supersede *decumanus*. The name *norvegicus*, however, dates from Berkenhout (1769), and since his description was based ostensibly on British specimens, the type locality is technically Britain and not Norway. As a name, *norvegicus* is a complete misnomer, since the species is no more than a modern introduction in Norway, as also in Britain; moreover, many of the pre-Linnæan writers, such as Ray, used "*Mus norvegicus*" (the spelling subject to variation) as the name of the Norwegian Lemming. Such objections, however, have no force technically, and on the ground of the rule of priority, applied only to Linnæan writings, *norvegicus* must stand as the trivial name of the present species.

Terminology:—This is the "Norway Rat" of Pennant (*Brit. Zool.*, i., 115), Berkenhout (1769), Shaw, and Turton; the "Brown Rat" of Pennant (*Quad.*, ed. 3, 1793, ii., 178) and most subsequent writers, although some, like Bingley and Bell, retain "Norway Rat" as an alternative name. Other names, which are or have been occasionally used for it, are "Wharf Rat," "Barn Rat," "House Rat," "Gray Rat," "Water Rat," and "Hanoverian Rat" (for origin of which last, see below under History). It is now generally known as the

"Common Rat," the name adopted here as being free from ambiguity (see p. 579).

Sex names:—*Buck* and *doe*; *dog* and *bitch* (occasionally); and *boar* and *sow* (amongst fanciers).

Local names:—"*Ratten*" or "*rotten*" of parts of Yorkshire and Scotland (E. R. Alston).[1]

Distribution and history:—The Common Rat is undoubtedly an Asiatic species, and has found its way to Europe only within the last two centuries. What precise part of Asia is to be regarded as its original home, has been the subject of considerable controversy. Pallas did not find it in Siberia, and Gmelin erroneously[2] claimed to have discovered it, inhabiting burrows in the fields in considerable numbers in Persia. Pennant, reflecting on these facts, and having heard of the Indian Bandicoots and their habits, conjectured that it had been brought from Persia and the East Indies to Western Europe by shipping. This view was maintained by many subsequent writers, and in 1852 Frank Buckland (*Curiosities Nat. Hist.*, i., 62) said:—"It is now agreed by most naturalists that it is a native of India and Persia; that it spread onwards into European Russia, and was thence transferred by merchant ships to England and elsewhere."

When, however, the mammals of India came to receive serious attention it soon became evident that this species was not a native of that country, it being met with only in the neighbourhood of certain ports; and Blyth was led to "suspect that the Trans-Baikalian region of East Asia had at least as good a claim to the *discredit* of originating the abominable brown rat as any other." Blanford, finding the species to be at present unknown in Persia, and to occur in India only along the coast and navigable rivers, arrived at much the same conclusion; he thought that Chinese Mongolia might with more likelihood be looked upon as its centre of dispersal. In China several short-tailed species, of smaller size but more or less closely resembling *norvegicus* in colour, occur. Thomas, receiving what purported to be a specimen of one of these, viz., *E. humiliatus*, Milne-Edwardes, was led to suggest this species as the possible wild stock of *norvegicus* (*Proc. Zool. Soc.*, 1898, 772); this specimen had, however, been incorrectly determined in Paris, and was in fact *norvegicus*, which is not uncommon in many parts of China (Bonhote, *Proc. cit.*, 1905, 393).

Kastchenko (*Ann. Mus. Zool. Acad. Imp. Sci. St. Petersb.*, xvii., 1912, 370) has described a wild form, his *E. norvegicus primarius*, inhabiting the region west of Lake Baikal, thus confirming Blyth's

[1] "When I was a boy, in the vicinity of Edinburgh, it was considered no mean feat to be able to say rapidly and correctly the words, '*A rotten loupit o'er a rope*; *loup*, *rotten*, *loup*,' and go on repeating them" (W. Evans, MS.).

[2] The rats found by Gmelin were probably "wild-coloured" forms of *E. rattus*.

suggestion noted above; the westward range of this form extends through Irkutsk between latitudes 53° and 59° N., to Jenisseisk and Krasnojarsk, near the meridian of 90° E. The Asiatic range of typical *norvegicus*, according to Kastchenko, extends northwards from the shores of the Caspian Sea from about 47° to about 59° N. latitude, and eastwards almost to Tobolsk, near the meridian of 70° E. In the region between 70° and 90° E. longitude, and the whole width of Asia north of 60° N. latitude, there is no wild representative of the species—a fact in accord with the experiences of Pallas and Middendorff. This discontinuity of distribution may perhaps be regarded as proof of the ancient standing of *E. norvegicus* in Asia.

It is possible that *E. norvegicus* was known to the ancients because, as suggested by Pennant and more recently by Blasius, the "*Mures Caspii*" described by Ælian (*Anim.*, 47) as "little less than Ichneumons, making periodical visits in infinite multitudes to the countries bordering the Caspian Sea and swimming boldly over the rivers holding by one another's tails," may have been of this species; these were referred to by Gesner under the name *Mus aquatilis*.

The species first appeared in Europe in the beginning of the eighteenth century, and it came both by land and sea. Pallas records that in 1727, which was a "mouse year" in the Caspian region, vast hordes of these rats migrated westwards after an earthquake; they swam across the Volga, the bed of the river being choked with them, and entered the houses of Astrakan in such numbers that nothing could be preserved from them. From Astrakan the species gradually spread westwards across Russia to the Baltic; according to Bujak (quoted by Blasius) it did not reach East Prussia before 1750, but Zimmermann speaks of it as common in Brunswick in 1780.

The earliest records of its arrival in Western Europe by sea are provided apparently by the memoranda (cited recently by Winge, *Danmarks Pattedyr*, 1908, 87) written in 1755 by Amtmand Urne of Bornholm, and now preserved in the Zoological Museum of Copenhagen. Urne states that he had heard that these rats arrived at Copenhagen with the Russian fleet, which visited that city in 1716; he records that they landed about 1725 from stranded Russian ships at Svaneke on Bornholm, and that by 1755 they had nearly extirpated the Black Rats at Bornholm.

According to R. Brown (*Arctic Manual*, 1875, 21), the species was carried to Greenland by Danish ships as far back as the days of Fabricius, *i.e.*, prior to 1780.

Collett states that the earliest Norwegian record is contained in Ström's MS. diary (1756-1780), now deposited in the University Library of Christiania; Ström says that these rats arrived at Söndmör from one of the neighbouring islands in 1762 and 1763, that they were

called "Sö-Rotter" or sea-rats, and in 1776 had become so numerous as to be called the "common kind." According to Svabo,[1] this species was first introduced to the Færöes in 1768 by a ship called *The King of Prussia;* while on a voyage from Norway to Dublin, this vessel was wrecked on the coast of Lewis, and the wreck drifted thence to Suderö. The species spread quickly throughout the islands, and was called by the inhabitants "the great or new rat," in contradistinction from the "common rat" (*rattus*) with which they had long been familiar. Svabo gives much information, with dates, relating to the progress of this species in the Færöes between 1768 and 1781. In Sweden it does not seem to have been known before 1790, and the earliest mention of it appears to have been made by Thunberg in 1798.

In France the species was said by Erxleben to have arrived at Paris in 1750, but it was not known to Buffon prior to 1753. It did not appear in Switzerland before the beginning of the nineteenth century (1809, Schintz, Blasius, and Fatio). In Spain its introduction dates from the end of the eighteenth or the beginning of the nineteenth century (Cabrera); and in Italy perhaps from the middle of the eighteenth century (de Selys; Nickel, *Zool. Garten*, 1874, 155).

A certain wealth of tradition has gathered around the advent of this species in **Britain**. According to one old legend it first came to **England** from Germany in the very ship which brought William of Orange over in 1688 (Charles Waterton's *Essays on Nat. Hist.*, ser. 1, 211); and according to another, positively supported by Waterton's father, it accompanied the House of Hanover on its emigration from Germany in 1714—hence the name "Hanoverian Rat," frequently bestowed upon this species by the British in the eighteenth century. Others, as Smith (*Universal Directory*, etc.), maintained that it came from Norway in timber-laden ships—an impossibility, because the species at that time did not exist in Norway. Pennant put the date of its introduction to England as about 1728 or 1729, and this date has been adopted by Boyd Dawkins, and most other writers. In all probability we received our first stock with cargoes from vessels trading with Russian ports.

Its arrival in **Scotland** dates from the period between 1764 and 1774, according to Walker (*Mammalia Scotica*, 498), and it reached Selkirkshire between 1770 and 1777; its progress from Selkirk to the upper valley of the Tweed, between 1776 and 1792, is narrated in the

[1] Svabo's unpublished MS. reposes in the library of the University of Copenhagen, and was the chief source of the zoological information given by Landt (*Forsög til en Beskrivelse over Færöerne*, Kjöbenhavn, 1800). We are greatly indebted to Dr Knud Andersen for the loan of his MS. copy of parts of this important work.

New Statistical Account of the Parish of Newlands, Peeblesshire, 1834, 137; the date of its arrival in Morayshire is given as about 1814 by the Rev. G. Gordon.

We have no certain information as to the date of its introduction to **Ireland**, but this probably happened soon after the arrival of the species in England. Rutty (*Nat. Hist. of Dublin*, i., 281) says, however, that it "first began to infest these parts about the year 1722."

The species first arrived in the United States of America, probably from England, about the year 1775; according to Audubon it was still unknown from the Pacific coast in 1851, although its introduction must have occurred there soon afterwards (Lantz, *The Brown Rat in the United States*, 1909, 13).

The success of this animal as a colonist seems largely dependent upon temperature and climate; but the abundance or scarcity of food, the presence or absence of suitable shelter, and the nature of the competition to be faced, are doubtless factors of equal importance in governing the distribution of this, as well as of other species. It has therefore met with varied fortune in the many lands it has invaded. In India, where the *rattus* group is at home, the foothold of *norvegicus* appears insecure; its colonies do not spread far from the landing places, and it seems wholly incapable of displacing the native rats.[1] In warm temperate countries, like Italy and Spain, it has acquired a good footing, but is forced to share the land with the "wild-coloured" sub-species of *rattus*. In temperate Europe its success has been marked; it has spread everywhere and has practically ousted *rattus*. Similarly on its arrival in New Zealand it promptly extirpated "*Mus maorium*," Hutton, *i.e.*, the descendant of the *rattus* stock previously introduced by Europeans. In Switzerland its progress has been slow; it appears to have entered from Germany across the Rhine and Lake Constance, and by 1869 had become common in some of the central Swiss cities, as Berne and Lucerne; but although at that time known from many towns and several cantons, it had nowhere risen to any notable height in the mountains; and Fatio doubted whether it was established then at Geneva, where the *rattus* group still predominated. In Sweden and Norway it has almost completely displaced *rattus*, but its range shows limitations similar to those of its predecessor, and it is scarce in the most northerly districts. In Norway its advance is said, by Collett, to be slow; it seems unable to colonise the upper parts of the main valleys, and is lacking from the floors of all the tributary valleys; it is still scarce or wanting in many of the coastal districts and inhabited islands. In northern Norway it occurs only in buildings or in certain market places, as at Tromsö and Hammerfest,

[1] Bonhote (*Proc. Zool. Soc.*, 1910, 65) says, however, that *norvegicus* is gradually increasing in East India and Egypt at the expense of *rattus* and other rats.

and when introduced in some localities it has quickly disappeared again. At Tromsö, however, it appears to have met with suitable hospitality, for rewards were paid for 4104 killed there between September 1909 and February 1911.

In America it inhabits most of the thickly populated parts; it occurs from Panama northwards to the Yukon Valley and to Greenland, except on the interior table-lands, and perhaps in a few sections of the south (Lantz). It is very common in California, chiefly in the towns; but in the San Joaquin and Sacramento valleys it has invaded marshy tracts, and occurs far from human habitations (Grinnell, *Proc. Cal. Ac. Sc.*, 1913, 322). It is found also in many parts of South America, where it is often the dominant species; but in the warmer parts of America it is frequently unable to supplant the previously introduced *rattus* group.

It was found on the ship *Advance* of Dr Kane's second Grinnell Land expedition during two icebound winters in 78° 37′ N. latitude; and it also adapts itself to the continuous low temperatures of cold-storage stations (Lantz). Brown says that when carried to Greenland in the time of Fabricius these rats "seemed likely to prove dangerous in houses; but they gradually and periodically died out, as they could not stand the cold of winter. Some years ago they were again introduced, and still occasionally one is seen in the summer months in some of the warehouses from Upernavik to near Cape Farewell." It is therefore unlikely that this species could survive for many generations under very severe climatic conditions; and possibly its present discontinuous distribution in Asia, noticed above, is to be explained as a result of the great changes of climate which apparently ensued in the northern and central parts of that continent towards the close of the Pleistocene.

The species is now widely distributed throughout **Great Britain** and **Ireland**, and it has reached the majority of the islands around the coast, being found on Jersey, Guernsey, Wight, Scilly, Lundy (Coward), Anglesey (Coward, *in lit.*), Man, Skye, the Hebrides, Ailsa Craig; on smaller Scotch islands, as Sanda, Sheep, Glenimore near Kintore, Sgat Mhor in Loch Fyne, and Inch Moan (Boyd Watt); on Orkney (Barry, *op. cit.*, and Wolley, *Zoologist*, 1849, 2344), Shetland, the Saltee Islands (Barrett-Hamilton, *Zoologist*, 1891, 6), Clare Island, and Inishmore. Drane did not find it on Skomer, and it is not known to occur on St Kilda.

Distribution in time, and origin:—Nothing is definitely known of the geological history of *E. norvegicus*. As shown above, its place of origin is apparently temperate Asia, where it probably dates from the Pleistocene.

Status:—The present species appears to be rather more specialised

than is *E. rattus*, and in a somewhat different direction. While *rattus* is essentially fitted for a free, semi-arboreal life, *norvegicus* has pursued a more earth-bound course. It has acquired accordingly a stouter and heavier body, a shorter tail, and its structure, in many points, has suffered modifications adapting it for burrowing, swimming, and the other activities incidental to its peculiar mode of living.

Description:—Though generally resembling *E. rattus* in form, the Common Rat is characterised by its relatively large size, great weight, robust form, short, thick ears, and by its shorter tail, which is never as long as the head and body.

The snout is relatively blunt. The eyes are small, though somewhat larger than in *rattus*. The **ears** are short, about one-third as long as the head and scarcely reaching the eyes when laid forward; their substance is thick and opaque, and they are clothed with fine short hairs; in young animals they are relatively large and thin. The **hands** and **feet** are much like those of *rattus*, although more robust; the fingers and toes have similar proportions, and the number and positions of the palmar and plantar pads are essentially the same in both species. The pads, especially those of the sole, are, however, relatively small in *norvegicus*; in the hand and foot there is sometimes a small free pad external to that at the base of digit 5; and in the foot another is occasionally present, to the inner side of that at the base of digit 1. The **tail** differs from that of *rattus* in being shorter and stouter, while the annulations are masked to some extent by the greater distinctness of their component scales; it has about one hundred and eighty rings in all, and a few small hairs rise from beneath each scale. The female has twelve mammæ, arranged as two pectoral, one abdominal, and three inguinal pairs.

Pelage:—The underfur is thick. The grooved bristles are much finer and present in much fewer number than in *rattus*, the long black dorsal hairs are shorter; in consequence of these differences the fur as a whole is rather softer and less harsh in quality than that of *rattus*, but the greater length of the underfur imparts a rougher and shaggier appearance, particularly noticeable on the belly, than that of *E. rattus rattus*.

The whiskers are relatively short, not extending beyond the ear when pressed backward; the lower ones are whitish, the remainder black in colour.

In the typical form the **colour** is darker on the back, where the tips of a greater or less number of the hairs are black, and lightens towards the sides, where dirty yellowish or whitish hair tips predominate. The general tone of the upper parts is a very variable greyish-brown, lined with black, and with an occasional reddish tinge over the rump and loins. The underside is variably lighter, the colour of the belly varying

from silver to a light yellowish-brown. Except under the chin, where the hairs are white throughout, all the hairs have slaty or dusky bases. The ears are of a dull hair-brown. The hands and feet are greyish flesh-coloured (not pink as in *rattus*). The tail is inconspicuously bi-coloured, being a dull dark brown above and yellowish-white below; the fine hairs, which clothe it but do not conceal the skin, are blackish above, whitish below.

Barrett-Hamilton observed the **moult** in a specimen of "*hibernicus*" taken at Kilmanock on 3rd August 1912. There is probably also a spring moult; O. Jones (*A Gamekeeper's Notebook*, 26) says the coat is rusty red then, especially if the rats are living in burrows in soil, and if short of food or living on carrion, which delays the moult. It is probable that all murines have distinct summer and winter coats.

The pelage of the **young** (soon after they have left their dam) does not differ conspicuously from that of the adults: it is rather softer, fuller, and duller in colour. The young are slenderly built; their ears relatively thin and, together with the tail and feet, relatively longer than in the adults. On cursory examination they may easily be confused with *rattus*, but all may be correctly determined by comparing their proportions with those of *rattus* of similar age, apart from the quality of the fur and the characters of the skull.

Local variation:—William Thompson's (*Proc. Zool. Soc.*, 1837, 52) description of the **Irish Rat**, *Mus hibernicus*, has given rise to a bulky literature. It was supposed to be characterised by the possession of white fore-limbs and of a white breast spot, but these have since proved to be very variable characters, more frequently absent than present, the chest spot when present being of various and often asymmetrical shapes. Apart from these features, *hibernicus* differs from ordinary brown specimens in the uniform dusky hue of the complete pelage and the absence of a white underside; and it is, in this respect, parallel to melanisms of the rabbit. The skin also is dusky, and a peculiarity is the frequent presence of numerous grey hairs on the flanks, which give a very blue appearance.

No doubt owing to its black colour, it was compared by Thompson with *E. rattus*, and in Bell's 2nd edition it is mentioned by Tomes in the article on that species. Others (as Southwell, *Zoologist*, 1889, 321, and *Trans. Norf. and Norw. N. H. Soc.*, ii., 419) have thought it a hybrid. While fully cognisant of these errors, Eagle Clarke (in Harvie-Brown and Buckley's *Vert. Fauna of the Outer Hebrides*, 1888, 36*a*) was at first led to regard it as a distinct species, but later (*Zoologist*, 1891, 1) he joined Barrett-Hamilton in describing it as an interesting melanism of *E. norvegicus*, an opinion already expressed by Blasius in 1857, and by de l'Isle in 1865 (*op. cit.*, 189). The latter used *hibernicus*, together with the melanistic races of House Mice, in

support of his argument, reviewed above, as to the origin of the black pelage in *E. r. rattus.*

This melanism was at first supposed to be confined to Ireland; Barrett-Hamilton received reports of it from at least seventeen Irish counties, and there can be little doubt that it occurs in all the remainder. He notes that "its appearance is sporadic and irregular; in some years it is absent, in others abundant, in the same locality. The young exhibit the melanism from the beginning, and litters may consist solely of black individuals or of some of each colour; thus Pack Beresford sent me a brown female, whose family consisted of eight brown and two black young. Specimens exhibiting intermediate coloration are rare; I have examined a parti-coloured black and brown one (*Zoologist*, 1888, 142)."

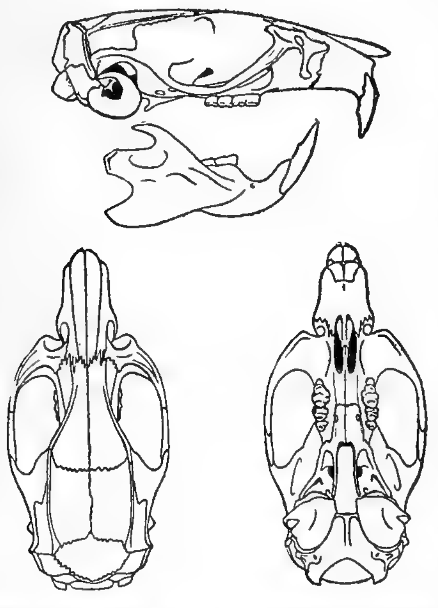


Fig. 91.—Skull and Mandible of *Epimys norvegicus* (life size). Reproduced from Miller's *Catalogue of Mammals of Western Europe*, by the kind permission of the Trustees of the British Museum.

This variation has now, however, been recorded from the Outer Hebrides; from many English counties; from Paris (Milne-Edwardes, *Ann. Soc. Nat.*, 1871, xv., art. 7); and Biarritz (a specimen from this last place seen by Barrett-Hamilton).

There can be little doubt that it is of frequent occurrence, but is confused with *E. rattus* or *Arvicola amphibius;* for instance, when observed in the Zoological Gardens of London it has done duty for *E. rattus* (see Millais, ii., 211; Pocock, *in lit.*, to Barrett-Hamilton). It seems to be a western development of the species, and to afford a close parallel, assuming de l'Isle's view to be correct, to the relations subsisting between *E. r. rattus* and the wild-coloured forms of that species.

The **skull** (Fig. 91) is strongly built and of relatively large size (the condylo-basal length usually more than 45 mm.). Compared with *E. rattus*, the brain-case is relatively narrower; the parietal region is much less conspicuously vaulted, and the rostrum is larger, especially deeper and broader. The dorsal profile is flatter and more nearly horizontal throughout. The masseter and temporal muscles are

relatively larger and more powerful than in *rattus*. The zygomatic arches are therefore heavier, and the masseteric plate is wider in proportion to its height. The temporal fossæ are more extensive, the parietal crests, which continue the supra-orbital ridges backwards to the hinder edges of the squamosals, running at a higher level (in an old skull of *E. r. rattus* the greatest distance between these crests equals 88 per cent. of the cranial width, but in a similar skull of *norvegicus* it equals 73 per cent. only); the greatest distance between these crests is about equal to the length of a parietal measured along a crest. The posterior border of the interparietal is nearly straight instead of boldly convex, and the backward deflection of the central part of the lambdoidal crest is correspondingly slight.[1] The auditory bullæ are rather smaller, and the anterior part of the basi-occipital is relatively a little wider. The processes of the premaxillæ supporting the nasals in front are relatively small.

The **mandible** is of normal murine form, with large angular and coronoid processes; the incisor roots produce well-marked though small humps on the outer sides, below the coronoid processes; the latter rise considerably above the condyles.

The **cheek-teeth** (Plate XXVIII., Fig. 9) are slightly more specialised than those of *E. rattus*. In the upper molars the median tubercles are somewhat increased in size, while the outer row is more reduced and the tendency towards lophodonty is more marked. In m^1 there is usually an anterior basal cingulum; cusp 1 is much smaller than x, and is fused with the latter from a relatively early stage of wear; cusps 4 and 5 are also smaller than in *rattus*, and more intimately connected with y and z respectively. Cusps 1, 4, and 5 can all be distinguished in m^2 and m^3 when slightly worn, and 4 is rather well developed, though smaller than in *rattus*, in m^2. In the lower teeth also the outer row is more reduced than in *rattus*; in m_1 it is represented by a minute cusp 6; in m_2 and m_3 cusp n is present though small, and in slightly worn examples of the m_3 the posterior lobe is seen to consist of two intimately connected tubercles—y and 4.

Some details of the **osteological** differences between *norvegicus* and *rattus* are given by de l'Isle (*op. cit.*, 219); most of the bones of the former differ from those of the latter species in showing larger surfaces for muscular attachment.

Exceptional variation:—The mammæ, as is well known, are rather variable in number in *norvegicus*, and also in *rattus*. Hossack found the typical $\frac{3-3}{3-3}$ formula in eleven out of nineteen specimens of *norvegicus* examined; the formulæ found in the remainder were: in

[1] Fig. 91 though giving a good general idea of the skull, does not portray the normal appearance of the occipital region in this species.

four, $\frac{2-2}{3-3}$; in one each, $\frac{1-1}{3-3}$, $\frac{4-4}{3-3}$, $\frac{3-3}{2-3}$, and $\frac{3-3}{4-3}$. Elmhirst (*in lit.*) notes one from Great Cumbrae with the formula $\frac{4-3}{3-3}$.

Hairless rats have been recorded by Bree (*Field*, 5th Oct. 1872, 328), who sent two to the Royal College of Surgeons; one, almost hairless, with transparent yellow skin, is mentioned by Millais (ii., 232); one from Leyton, Essex, is recorded by Beddard (*P. Z. S.*, 1903, ii., 336); and another from Devonport by Belcher (*Zoologist*, 1904, 72).

A very large number of colour variations have been recorded for this species, a circumstance due to the density of the rat population and the enormous numbers which come under observation rather than to any greater instability of coloration than in allied species. Space will not permit of a complete list of the variations which have been observed among wild rats, but they may perhaps be classified as follows[1]:—

1. Pure albinos; white with pink eyes.

2. Partial albinos; including silvery grey, fawn, and sandy animals, with or without pink eyes.

3. Partially or completely melanic individuals.

In some cases the variation affects the whole coat; in others it is only seen in portions of the coat, so that spotted, pied, or particoloured rats are the result.

Such variations are frequently transmitted by heredity, and may become characteristic of local races. The most striking instance of this sort is, of course, that afforded by *hibernicus* discussed above. Lord Headley discovered a peculiar race on an island in Lough Corrib, Co. Galway; eleven caught there were buff or fawn, "desert" coloured rats, with ruby eyes. Millais mentions sandy coloured rats found on the seashore of Tiree, and he compares them with the peculiar House Mice of North Bull, Dublin.

E. norvegicus is frequently bred in captivity, and many variations of colour and pattern have shown themselves in the course of domestication; these variations have been studied by Crampe, Doncaster, Mudge,[2]

[1] Reference may be made to the following, though quite incomplete, list of the literature for details of representative cases:—G. B. Corbin, *Zoologist*, 1873, 3525; J. Gatcombe, *ibid.*, 1874, 3996; J. Sclater, *ibid.*, 1876, 5039; B. H. (Llandudno), *Field*, 1st August 1885, 192; E. W. Gunn, *Zoologist*, 1889, 144; G. T. Rope, *ibid.*, 1890, 97; R. I. Pocock, *Field*, 22nd June 1907, 1063, and 18th May 1912, 997; and A. J. Bengough, *ibid.*, 2nd December 1911, 1234. Other cases are noted by Millais (ii., 221). Cocks has seen an immature albino male in Bucks, and Service informed us of a light grey or grizzled white rat taken in July 1903.

[2] Crampe, *Landwirth. Jahrb.*, 1885, 539; L. Doncaster, *Proc. Camb. Phil. Soc.*, xiii., 1905, 215; G. Mudge, *Proc. Roy. Soc.*, 80, 97, 1908.

and others, from a Mendelian standpoint. Pocock[1] states that all the fancy rats kept or seen by him were unmistakably specimens of *norvegicus;* and Lantz[2] says that the only albino rats in the collections of the United States National Museum and Biological Survey are of this species. It is therefore very doubtful, despite statements to the contrary,[3] whether any of the tame rats of commerce are other than *E. norvegicus.* Lataste (314) thinks that the white variety is the commonest and most ancient of these tame races—it being known to his friends from at least about 1857—and that the other varieties are rarer and more recent productions. Millais (ii., 218) says that although there was a National Mouse Club in the nineteenth century, it was not until the twentieth century that classes for fancy rats came into notice at the shows.

Brehm (*Thierleben*, ii., 125) mentions artificial "King Rats" (see p. 592) as known in 1774 and 1822, and Lataste (352) thinks they must have been tame *norvegicus.* Blind rats (four out of a litter of five) have been recorded by Cocks (*Zoologist*, 1903, 430), who informs us (*in lit.*) of two other cases from Poynetts, near Henley, viz., three out of five young rats (head and body, 100 to 110 mm.) on 8th January 1904, and another about two-thirds grown on 16th July 1914. The cause of the blindness appears to be obscure though post-natal (see below, p. 641).

Geographical variation :—The only race at present recognised as a distinct sub-species from the typical European Brown Rat is *E. n. primarius*, Kastchenko, described from the Trans-Baikal region. This form is represented in the British Museum collection by a series collected in July 1914 by Mr G. A. Burney at Musavaia, Trans-Baikal, and Leestvineechnova, Irkutsk. It is characterised by its somewhat shorter tail (averaging about 76 per cent. instead of about 82 per cent. of the length of the head and body); smaller hind feet (31 to 37·5 mm.); longer and softer fur, and darker dorsal coloration. The tail is rather densely clothed with very fine silvery hairs; its skin is distinctly bicoloured in younger specimens, but apparently has a tendency to become paler above with advancing age. The feet are silvery white. The young have a very soft and full coat, dusky above, leaden below; a few of the hairs on the head and shoulders have yellowish-brown tips, while those of the under parts are silver-tipped.

[1] R. I. Pocock, *Field*, 15th June 1907, 1015; and *ibid.*, 18th May 1912, 997. Capt. S. Flower mentions, in the *Report of the Giza Zoological Gardens*, the births of many white rats of this species in 1907 (see also *Field*, 27th June 1908, 1117).

[2] D. E. Lantz, *The Brown Rat in the United States*, 1908, 14.

[3] *Cf.* Millais (ii., 217): "It is scarcely necessary to say that all the rats sold in the fanciers' shops are domesticated varieties of *Mus rattus.*"

DIMENSIONS IN MILLIMETRES:—

EPIMYS NORVEGICUS.

SEXUALLY MATURE SPECIMENS FROM KILMANOCK, WATERFORD, IRELAND, CAUGHT AND MEASURED BY G. E. H. BARRETT-HAMILTON.

Males.	Head and body.	Tail (without hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.	Females.	Head and body.	Tail (without hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
1. Undated . .	216	178	36	20	..	1. Undated . .	229	178	40	21	..
2. ,, . .	216	191	38	18	..	2. 13th Mar. 1908	267	184	40	20	453
3. ,, . .	222	..	40	20	..	3. 10th Aug. 1909	216	178	38	21	..
4. ,, . .	222	165	..	20	..	4. 13th Oct. 1910	267	203	40	20	..
5. ,, . .	241	203	42	23	..	5. ,, ,, ,,	222	178	38	19	..
6. ,, . .	229	178	41	21	..	6. ,, ,, ,,	235	178	35	20	..
7. 13th Mar. 1908[1]	254	222	43	20	453	7. ,, ,, ,,	241	203	39	19	..
8. 10th Aug. 1909	229	197	40	21	..						
9. ,, ,, ,,	229	..	40	21	..						
10. ,, ,, ,,	203	178	40	21	..						
11. 13th Oct. 1910	273	..	41	20	..						
12. ,, ,, ,,	254	178	40	20	..						
13. ,, ,, ,,	229	203	38	21	..						
14. ,, ,, ,,	229	216	40	20	..						
15. ,, ,, ,,	235	..	40	20	..						
16. ,, ,, ,,	235	203	41	20	..						
17. ,, ,, ,,	210	203	41	20	..						
18. 8th Mar. 1911 .	267	229	45	20	502						
19. 20th Sept. ,,	241	..	41	19	516						

[1] Males Nos. 7 and 19 were black specimens ("*hibernicus*").

Weight:—Of twenty "ordinary" and apparently adult rats weighed at Kilmanock on 13th October 1910, fifteen males averaged 13·6 ounces, or 385 grammes, and five females averaged 14·5 ounces, or 411 grammes. Higher weights are given in the table above, but specimens weighing more than 17 ounces, or 481 grammes, are exceptional. Two examined by the editor of the *Field* reached 20·5 ounces, or 581 grammes (a male), and 23 ounces, or 651 grammes, respectively (*Field*, 30th July 1887, 199, and 5th January 1889, 27). Neglecting anonymous records, there are at least six other records in the *Field* of weights of over 20 ounces; of these the two heaviest are here given for what they are worth:—A male, 29 ounces, or 821 grammes, killed 1st January 1900 (R. B. Whitford, *Field*, 20th January 1900, 95); one, 31·5 ounces, or 892 grammes, killed in 1883 (F. W. Cock, *Field*, 21st January 1888, 91); but it would be safer to take the 23-ounce specimen examined by the editor as holding the record.[1]

Skull:—Condylo-basal length, 43·4 to 54·2; zygomatic breadth, 20·2 to 28·6; interorbital constriction, 6·2 to 7·6; occipital breadth, 16·2 to 21·2; median occipital depth, 10·4 to 13·4; length of a nasal,

[1] It is worthy of note that this specimen was sent in as weighing 28 ounces; it must be remembered, however, as Mr Cocks points out, that animals when dead very soon begin to lose weight.

16·4 to 22; diastema, 12 to 15·6; maxillary tooth-row, 6·8 to 8·8; mandible, 26 to 33; mandibular tooth-row, 6·8 to 8·4.

Distinguishing characters:—The Common Rat in all colour phases is readily distinguishable from any sub-species of *E. rattus* by its stouter build, greater weight (in relation to length of head and body), shorter tail, shorter and thicker ears, and its larger hind feet. The skull is characterised by its greater size and the peculiarities of form in the parietal and interparietal regions described above.

The Common or Brown Rat is probably the most injurious and universal mammalian pest of the human race, and its habits are so well known as not to require description; or, rather, they are so wide as to be comparable with those of man himself, and would therefore require a volume for exhaustive treatment. It does not appear to have a single redeeming feature, its value as a scavenger being now negligible.

Disregarding exceptional conditions, rats are wide-foraging animals, dwelling in secure burrows,[1] where they lie up in a warm nest of grass or other materials, and to which they carry their food, at least when abroad by daylight; but probably from reasons of prudence their forays take place chiefly at night. Being powerful diggers, they are quick to construct new burrows in the neighbourhood of food, and sometimes these are merely temporary shelters, not occupied for purposes of sleeping. The proximity of the food supply usually governs the situation of the burrow, but there is no rule for its extent or situation; it generally consists of several winding galleries, and possesses more than one entrance. The animals are apparently loth to make unnecessary excavations, and they are quick to burrow in heaps of soft material, such as manure (which is also warm). For the same reason, perhaps, they are great frequenters of ricks,[2] which also supply them with food; of the burrows of rabbits, where they devour the young; and above all of dwellings and outhouses, where they lie up in the floors, walls, or more rarely, in the roofs (though common in thatch). Their teeth are so powerful that they rapidly gnaw a way through wooden partitions; they have been known to damage

[1] Sometimes at a distance from their food—see *Field*, 17th July 1886.

[2] Owen Jones records the capture of 600 rats from one rick, 1000 from two, and 1300 from three other ricks.

lead pipes,[1] and will even break through cement if they can attack it before it has hardened. Sometimes they construct clumsy nests, like those of the House Sparrow,[2] in thick bushes or hedges.

They have a special propensity for exploring underground passages, such as sewers or drains, where no doubt they pick up much food; and, as they swim and dive with almost as much facility as purely aquatic mammals, they thus tend to be found in exceptional numbers by streams or rivers, with consequent damage to embankments and reservoirs.

Where they are abundant they make beaten paths or "runs," distinguishable from those of rabbits by the continuously smoothened surface, since the stride is much shorter than that of rabbits, and by the spindle-shaped droppings.

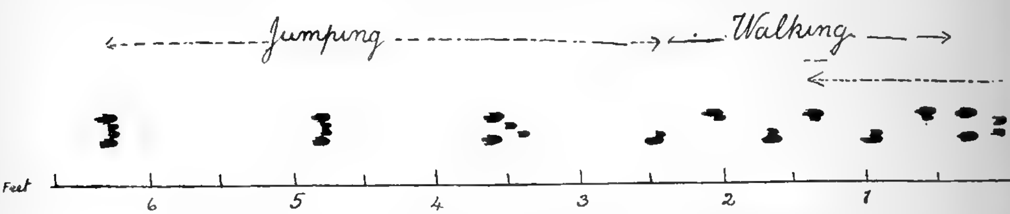


FIG. 92.—SPOOR OF RAT (Diagram from sketch and measurements made by Barrett-Hamilton at Kilmanock.)

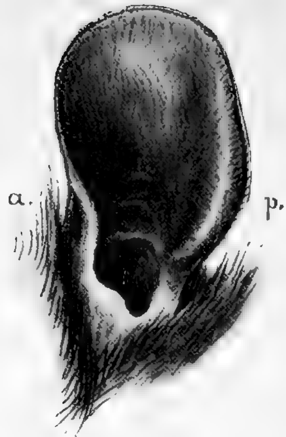
One such pathway leading from burrows to a feeding place is said to have measured 500 paces in length.[3]

The tracks of rats (Fig. 92) show that when walking the hind feet tread partly upon and partly to the outer sides of the prints left by the corresponding fore feet, the length of the stride being between 8 and 10 in. As the pace increases the animal breaks into a series of leaps and covers a distance of from 13 to 18 in. at each bound. In these leaps the hind feet strike the ground together a little in advance, and to the outer side, of the prints left by the fore feet; the latter prints lie side by side close to the centre of the track. The extreme width of the track is about 3 in.

[1] Gnawing of lead from a sash-weight—H. Burroughes, *Zoologist*, 1852, 3473; leaden pipes (*Field*, 17th Feb. 1894, 230; *ibid.*, 10th March, 353 (illustrated), 24th April, 474. Specimens of gnawed pipes are in British Museum (N.H.).

[2] *Passer domesticus.* Whole "ratteries" were reported as existing in hedges in New Zealand—see *Proc. N.Z. Institute*, 1870, 47; and *Zoologist*, 1887, 189.

[3] Jesse, *op. cit.*, 231.



(1)

(2)

(3)

THE COMMON RAT—*Epimys norvegicus.*

(1) LEFT EAR (twice life size); (2) LEFT HAND AND (3) LEFT FOOT (one and a half times life size).

Without being specialists, they are excellent climbers, so that it is difficult to imagine a situation to which they could not penetrate. Barrett-Hamilton (MS.) says, "My own home is rat-proof as regards the basement, but a constant watch and ward is still necessary to keep rats from entering by open doors and windows, and they have several times, by climbing up the walls, found their way to the roof. In climbing, the tail is used as a balancing organ, and to a very small extent tends to be prehensile, especially when the animal is descending, opportunity being taken to twine it round any available object."[1]

One of the chief factors leading to the success of rats is their excellent social system. Although the old males seem to live apart[2] in special burrows of somewhat simple construction, the bulk of the species are eminently sociable animals, not separated off in mutually exclusive clans like Water Rats. This is shown when one is introduced into a receptacle containing other rats. Unless one be wounded no objection is raised to the arrival of the new-comer, who, although a stranger, is invariably received as a comrade. Perhaps for this reason a man can insert his hand amongst a lot of caged rats and handle them without fear of being bitten;[3] and where a rat is killed its place is rapidly occupied by another so long as any trace of the original one remains, either by way of smell or otherwise. Similarly in a garden one may grow tulips for years without their being discovered by rats. Should, however, one rat discover and dig for the bulbs, it is little use trapping him, for every rat that passes will be attracted by the "signs" of its predecessor. They are diabolically intelligent animals, and where a bed in a garden has been recently dug over, will excavate anything planted in it, apparently for the sake of curiosity.

So intelligent are these animals, that they are believed to resort to combination for the attainment of a desirable object, as when two assisted each other to push a dog-biscuit through

[1] *Cf.* Millais (ii., 181), who points out that in the Dormouse the tail is only a balancer; in rats and mice it is almost prehensile; while in the Harvest Mouse it is specialised for prehension.

[2] A. H. Cocks, *Bucks.*

[3] Cocks says this is so if there are not fewer than three rats present.

the bars of a cage.[1] This is a point, however, at which narratives tend to verge on the poetical.

Unlike the various wild mice, rats are very suspicious of traps, but often succumb to their propensity for running through holes or apertures; for instance, if two boards be placed on their sides so that the "run" passes through a narrow aperture left between the boards, the rats will use the fenced part of their pathway rather than climb over one of the boards, and may thus be trapped.[2]

Although Common Rats frequent houses and ships, they do not succeed so well in these situations as the Black Rat, which is a far superior climber.

The dietary of the Common Rat is very wide, almost as wide probably as that of the domestic pig. The food of any particular rat varies with its situation. In Ireland they are so abundant that practically every part of the country, except the bare hillsides and possibly the forests, is overrun with them, and consequently the food available for any particular individual is peculiar to its habitat. But should one food fail, the animal is always ready to take to another, thus rendering starvation a remote possibility. On the seashore the food is what is cast up by the sea, together with prawns, shrimps, shell-fish, fish, eggs and young of sea birds,[3] and vegetable matter; in marshes or pastures, mushrooms, frogs and their spawn, toads, mollusca,[4] insects,[5] fish, and small

[1] T. W. Kirk, *Nature*, 10th September 1884.

[2] Owen Jones recommends setting the trap on the worn spot where a rat jumps down.

[3] These (or young chicks) are often removed from under the sitting bird without disturbing her. Much ingenuity is often displayed in removing them intact to the burrow; the methods used are mentioned on p. 415, article Bank Mouse. For sucking blackbirds' and robins' eggs, see R. Wayne, *Zoologist*, 1849, 2495; and for a case where an egg was removed by one rat embracing it, the other pulling it by the tail!—H. Moses, *Zoologist*, 1865, 9431 (seen by a clergyman).

[4] Including mussels—fresh-water or marine. Cocks tells us that, on the Thames, the Brown Rats bring ashore and eat large numbers of mussels. For the corresponding habit of the Water Rat, see p. 494. In some parts of New Zealand they are stated to have almost extirpated a native species of crayfish and to dive for mussels (*Unio*); these latter they open on the bank (*Zoologist*, 1887, 189).

[5] Whence they receive the same tapeworms and other parasites as hedgehogs and small carnivora (Shipley, 65). Cocks has known rats to feed on the intestines of living ducklings.

eels;[1] in cultivated lands, all sorts of leaves, stems, flowers, roots,[2] or grain; in towns and houses, milk, butter, cheese, bread, flour, jam, and refuse of all sorts; on roads, the undigested portions in the droppings of animals; in game preserves, dovecots, or farmyards, young pheasants, pigeons, ducks, or poultry; in old walls, snails, rejecting the shells;[3] in meadows, grass-seed;[4] in orchards, fruit;[5] in warrens, young rabbits.[6] Everywhere and at all times young, small, or weakly vertebrates[7] are hunted with a ferocity suggestive of a lust for killing, since the victims are often left uneaten. Wherever domestic animals feed or are fed, a host of these marauders attends to assist in the meal or clear away the leavings. One result of this ubiquity is that it is of very little use for one person to trap and destroy them. Those killed amid the flesh-pots of a farmyard simply leave vacancies for their ravenous brethren of the barer fields.

It is quite marvellous how they discover where animals are fed. They even find their way into mines.[8] Barrett-Hamilton saw them chasing birds coming to feed on crumbs in times of snow, and they will take the water to quarrel with water-fowl at feeding time.

[1] Lamperns—E. Brown, *Zoologist*, 1843, 212. Eels—J. Hardy, *Zoologist*, 1846, 1364; R. Lydekker, *Royal Natural History;* Shipley, *op. cit.*, 65.

[2] Swedes—R. M. Barrington (*Zoologist*, 1878, 178) and many others have pointed out that in eating a swede, which they prefer to a turnip, rats gnaw right round the root, ending (if they do not pass on to another one) in the centre; they also bite off and reject bits of the rind, which lie conspicuously on the ground. Hares are also said to reject the rind (H. Miller, *Zoologist*, 1878, 100), but they and rabbits differ from rats in gnawing right through the root from one side to the other. Another and safer method of distinction would be afforded by the size of the marks made by the incisors of the three rodents.

[3] Snails—Merrifield, *Sketch of the Natural History of Brighton*, 157; Harting, *Zoologist*, 1887, 190, *Rambles in Search of Shells*, 73, and *Vermin of the Farm*, 4.

[4] Hence a handful of "hay-seed" is a very useful thing for sprinkling over rat-traps.

[5] Climbing the trees for apples and cherries (*Field*, vol. 78, 660); morella cherries, J. B. Ellman, *Zoologist*, 1848, 2223.

[6] Hence rabbit-trappers have frequently to kill off the rats in rabbit burrows before they can secure the conies. Puffin Island, off Anglesey (Robert Stephenson), and the Skerries, near Holyhead, are said to have had their stocks of rabbits destroyed by rats which escaped from shipwrecks (Pattisson in Bell, ed. 2, 313).

[7] Smaller rats—R. M. Barrington, *Field*, 1875, 4662. For conflicts between rats and hedgehogs—the former not always being the aggressors, see p. 62 above.

[8] "Coal-mines"—G. Roberts, Wakefield, *Zoologist*, 1867, 553.

Occasionally, as reported in the daily press for Midlothian and Lincolnshire in 1889, rats become so numerous as to constitute a recognised "plague." These increases are parallel to those occurring in other rodents, and may have been more frequent in former times when the Black Rat held undisputed sway in this country.

Food and other articles are always carried away, if possible, to the burrow. A single nest was found to contain three towels, two serviettes, five dust cloths, two pairs of linen knicker-bockers, six linen handkerchiefs, and one silk handkerchief; near this nest were $1\frac{1}{2}$ lbs. of sugar, a pudding, a stalk of celery, a beet, carrots, turnips, and potatoes.[1] Millais states (ii. 224) that 1728 gnawed serviettes were found behind the wainscot of a London restaurant.

A partial migration is performed according to season from the open country in summer to the shelter of farms and houses in winter; and similar movements take place where food varies with the season. For instance, herring fisheries are said[2] to attract large numbers to the coast every year, the rats returning inland on the cessation of the fishery in October. In foreign countries very much larger and more irregular movements have been noticed.[3]

Mr Cocks (*in lit.*) relates a remarkable experience in Heligoland many years ago. While walking along the cliffs he shot a Peregrine Falcon, which fell on the rocks below. As soon as the tide permitted he set off, along the shore, to retrieve his prize. It was an autumn evening, and "presently, in the complete solitude and silence, I was very much startled by a sort of rushing sound, as of countless feet. The next moment I began to be passed from behind by a legion of rats, numbering at least little short of, and quite likely considerably over a thousand, who made their habitat at the base of the cliff, and came out when the tide fell, looking for food. I never saw anything like it before or since. We did not interfere with each other, though they perforce had to pass me quite close."

[1] *Field*, 10th Jan. 1891, 46; Lantz, *op. cit.*, 29.
[2] Lantz, *op. cit.*, 17. [3] Lantz, *loc. cit.*

The rat flourishes on a shore diet. It thus manages to subsist on many of the smaller islands, as on Ailsa Craig, where it arrived in 1889, and eats the innumerable dead bodies of sea-birds falling to the bases of the cliffs.[1]

As a rule rats do not directly molest large animals, but they have been occasionally known to attack or kill men[2] or children,[3] and to gnaw the feet of elephants in the Zoological Gardens.[4] Their tendency to cannibalism is interesting in view of the fact that, as described above, they are at ordinary times friendly to all members of their species. Either they run amuck sometimes, or else they attack each other through some mistaken sense of injury.[5] Stories of rats eating each other when left over night in cages cannot be regarded as instances of their normal habits, since their sufferings from thirst and hunger probably madden them, and may lead them to connect their troubles with their comrades, as many "game" animals do when wounded by a shot from an unseen hunter.

Extraordinary calculations have been made as to the damage done by rats and the rate of their increase. F. von Fischer[6] calculated that a single pair might leave, after ten years, a progeny of 48,319,698,843,030,344,720 rats.

Mr Lantz[7] calculates that in nine generations a single pair of rats would, if breeding uninterruptedly, produce more than twenty million individuals, but such a calculation is entirely theoretical. However, as he states that the average quantity of grain consumed by an adult or half-grown rat is fully 2 ounces daily, or 45 to 50 lbs. a year, the average cost for feeding one rat for a year becomes about seven shillings and sixpence. If fed on meat, the cost would be higher, but the calculation is complicated by the fact that rats eat much waste products and, on the other hand, damage more than they eat. Many rats must each destroy fully five shillings' worth of

[1] Boyd Watt, *Ann. Scott. N.H.*, 1892, 132.

[2] In Walker Colliery, Killingworth, *fide* Robert Stephenson, M.P. (the distinguished engineer), quoted by Tomes in Bell, ed. 2, 311; see also Millais, ii., 229.

[3] Shipley, *Journ. Econ. Biol.*, iii., 1908, 65.

[4] Frank Buckland, *Curiosities Nat. Hist.*, i., 76; and Millais, ii., 229.

[5] Such highly "civilised" animals as dogs occasionally murder each other when confined together in numbers.

[6] *Zool. Garten*, 1872, 125.

[7] Lantz, *op. cit.*, 16.

property annually. The real numbers of rats are probably not realised by ordinary people. In 1901, about 37,000 were killed on a farm of 2000 acres near Chichester,[1] and over 12,000,000, mostly of the *E. rattus* group, were killed in certain parts of India[2] in the years 1878-79. Dr A. E. Shipley,[3] assuming the rat population of Great Britain and Ireland to be about 40,000,000, or one for every human being and slightly less than one per acre, estimated the total annual loss occasioned to us by rats at the huge sum of £10,000,000, while Sir James Crichton-Browne[4] has even placed the damage at £15,000,000 per annum.

Sometimes rats cause destructive fires by stealing and accidentally igniting lucifer matches,[5] or by gnawing through gas pipes they give rise to inflammable leaks[6] or asphyxia of the human inhabitants.[7] Sometimes they destroy the insulating covering of wires used for electric lighting,[8] which may again result in conflagrations.

Inasmuch as rats are quite palatable animals,[9] it might be thought that all flesh feeders[10] could live upon them; but their ferocity and vigour in defence is so great that most carnivorous creatures, though glad to catch the young, pause to reckon the consequences before attacking a full grown rat—if she be a doe with young her prowess is increased tenfold.[11] Only strong dogs, ferrets, or cats, will face rats, but

[1] *Field*, 27th Sept. 1902, 545.

[2] *Brit. Med. Journ.*, 16th September 1905, 623.

[3] Shipley, *op. cit.*, 66.

[4] *Journ. Incorp. Soc. for the Destruct. of Vermin*, i., 74, October 1908; for other countries, see Lantz, *op. cit.*, who calculates the annual loss to the citizens of the United States of America as \$20,000,000 = £4,000,000.

[5] As on H.M.S. *Revenge;* see Hardwicke's *Science Gossip*, v., 142, 1869.

[6] As in Phillip's warehouse, Church Street, London; see *Journal cit.*, x., 73, 1874.

[7] E. Newman, *Zoologist*, 1875, 4378.

[8] Lantz., *op. cit.*

[9] Owen Jones states that rat-pie tastes like rabbit if made from well-fed animals.

[10] For a horse killing a rat, see S. B. Wells, *Field*, 1st June 1912, 1110.

[11] Cocks (*in lit.*) says:—"While young rats are useful food for nearly any carnivorous mammal or bird, tough old ones are unwholesome for more delicate feeders, such as Wild Cats or many birds of prey. On one occasion more than twenty years ago, I put a fine old rat alive in, for the supper of a correspondingly fine male Wild Cat. Within a very few minutes the rat disappeared. On the sixth day afterwards, my man opened the door of the cat's 'bed-sitting room,' and found the rat there perfectly well. For five nights the cat and rat had slept side by side, and the rat had doubtless maintained itself by scraps from the Wild Cat's daily meals."

still, combined with trappers, professional or desultory, foxes, owls, and other creatures, together with the plan of bacillus infection, which appears to have met with some success recently, a large toll is annually taken, but seems to have no effect on their numbers. Sooner or later civilised man will have to face the problem of totally destroying these pests, but hitherto his efforts have met with practically no success. In Japan alone several hundred thousand to a million rats are said to be killed annually, but without producing any sensible diminution of the numbers present.[1] The cutting-off of the chief sources of food-supply, thus reducing the number of young, and the universal erection of rat-proof dwellings, as recommended by Mr Lantz,[2] if combined in a systematic manner with trapping, may prove more effective in the long run than the present desultory campaign.

Rats are extremely prolific, and when living in houses in warmth and plenty, will produce young at every season of the year; but this, of course, does not indicate that any particular female will breed throughout the year. Those who live out of doors and are more poorly fed have a sexual season varying with their circumstances, but coinciding more or less with the warmer six or eight months of the year.[3] Fertility is greatest in countries of mild climate free from extremes of heat or cold, but in exceptional cases winter litters are found even in severe weather in the open country.[4]

Darwin (*Desc. of Man*, ed. 2, 247) was informed that the males are "in great excess," while John Sinclair reported (Thompson, iv., 18) that 75 per cent. of the rats in litters he examined were males. Bonhote, however, found that in Egypt males were apparently fewer than females, constituting only 42 per cent. of those he examined; and of eighty-four examined at Kilmanock, on one occasion, only fourteen were bucks.

Tame female white rats are said to be capable of breeding

[1] Professor Kitasako, quoted by C. Hart Merriam, *U.S. Department Agric. Biol. Survey*, Bull., 23, 1909, letter of transmittal.

[2] *Ibid.*, 10. Much valuable information as to the best means of destroying rats or of protecting property and food from their attacks is given in this paper (pp 36-54).

[3] Heape found the diœstrous cycle to occupy about ten days.

[4] J. C. B. Noble, *Field*, 26th November 1904, 950.

when five weeks old, and no doubt wild does attain sexual maturity long before they are really full-grown. Shipley states that in Bombay sexual maturity is not reached until the weight is at least 100 grammes.

The period of gestation is about twenty-one days,[1] and the number of young in a litter is said to reach thirteen,[2] fourteen,[3] or sometimes twenty;[4] but many litters, especially those of young females, are very much smaller, and sometimes consist of a single young one only.[5] Mr Cocks has records of twenty-three litters[6] of pregnant does examined at Great Marlow and Poynetts; four of these contained 6; ten, 7; three, 8; two, 10; three, 11; and one, 12—giving an average of nearly 8 per litter. In one of 7 the fœtuses were of two sizes; 3, situated at distal end of right horn, being very small. Two litters of 7 and 5 respectively were obtained from a rat with only one ovary.[7]

The young are as helpless at birth as those of other murines, being blind, pink, and hairless, and with the ears sealed down over the auditory meatuses. They are carefully

[1] J. L. Bonhote, *in lit.*

[2] L. E. Adams, *MS.*

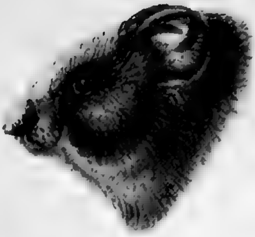
[3] Lantz, *op. cit.*, 15.

[4] Newton Miller, *Amer. Nat.*, xlv., 623, 1911; C. E. Wright (in Millais, ii., 230) found twenty young in a nest in a mole's fortress in Northamptonshire; C. H. Nash (Adams, *in lit.*) found a double nest containing two old and sixteen young ones, and Owen Jones found thirty-four little rats in one nest. Seventeen and nineteen embryos and twenty-two and twenty-three young in nests are quoted by Lantz from the *Field* (*op. cit.*, 15), but at Bombay the pregnant females of 12,000 specimens examined showed an average of 8·1, and a maximum of fourteen embryos (*Etiology and Epidemiology of Plague*, Calcutta, 1908, 9; and Lantz, *op. cit.*, 15).

[5] Newton Miller (*op. cit.*; and *Nature*, 26th October 1911), experimenting with captive Common Rats, found the period of gestation to vary between twenty-three and a half and twenty-five and a half days; the rats breeding in every month of the year. The female may produce five or six litters annually; the number of young per litter averaging between ten and eleven, and ranging between six and nineteen. One female produced seven litters in as many months, and it was presumed that in cases where all the young perished at birth there would be a dozen litters in the course of the year. The captives devoured 50 per cent. of their young at birth, most, if not all, of these being eaten by the females. Although full growth is not attained before the eighteenth month, sexual maturity is reached in both sexes at least as early as the end of the fourth month.

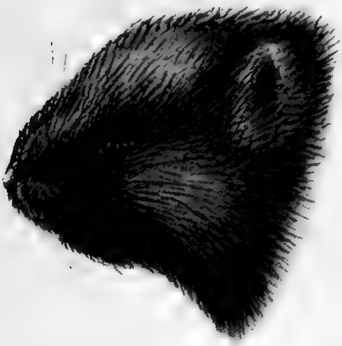
[6] Inclusive of those published previously in *Bucks* (*Vic. Co. Hist.*).

[7] L. Doncaster and F. H. A. Marshall, *Journ. Genetics*, 1, i., 18th November 1910, 70.



(1)

(3)



(2)

(4)

HEADS OF BRITISH *Muridæ*.

(1) BANK MOUSE. (2) WATER RAT.
(3) BLACK RAT. (4) COMMON RAT.

tended by their mother alone, who will carry them out of reach of danger, like other rodents, in her mouth.[1] An instance is recorded of a female, caught in a trap by one forefoot, gathering a nest of grass together for her six newly-born young.[2]

Space does not permit a description of the various methods of rat-catching,[3] which, as mentioned on p. 583, is an art of quite respectable antiquity. Black Rats or Common Rats, according to the period, figure quite frequently in Acts of Parliament, churchwardens' accounts, parish registers, and other documents.

Rats are popularly supposed to desert in a body a sinking ship,[4] or a building, when any ruinous injury exists in the masonry. There seems to be no definite evidence of these supposed facts, but unquestionably the movements or migrations of rats are largely governed by questions of food supply.

One generally supposes that rats find their way about by the exercise in an acute degree of the ordinary mammalian senses of sight, touch, hearing, and smell, but some experiments recently undertaken in the biological laboratory of Chicago[5] suggest that they possess a special motor sense of which human beings can have little, if any, cognisance, being independent of sight, smell, or hearing. The whiskers are an important, but not an essential, factor, since, although disturbed temporarily by the removal of the whiskers, the rats were forty-eight hours after the removal perfectly capable of finding their way about without them.

Rats make very attractive and amusing pets.[6] As shown above (p. 617) most, if not all, of the existing domestic breeds

[1] Eight young were seen thus transported by E. Cowley, *Field*, 18th March 1911, 538; Steele Elliot, *Journ. Birmingham Nat. Hist. and Phil. Soc.*, March to April 1896, ii., 17, saw mouse-sized young similarly transported.

[2] A. B. Hemsworth, *Zoologist*, 1848, 2132.

[3] In addition to the works of Smith and Swaine, cited on pp. 583-584, see Matthew's *Revelations of a Professional Rat-catcher*, 1898; H. C. Barkley's *Studies in the Art of Rat-catching;* James Rodwell's *The Rat: its History and Destructive Character;* Frank Buckland's essay on Rats, *loc. cit. supra;* and other works.

[4] See quotation from *The Tempest*, at p. 578 (Terminology).

[5] *Field*, 27th June 1908, 1117.

[6] Perhaps tamed in Japan first, *vide* Bingley, 253. Some of the Japanese tame these animals, and teach them to perform many entertaining tricks; and thus instructed, they are exhibited as a show for the diversion of the people (Kaempfer's *Japan*, i. 126).

belong to the present species. The behaviour of tame *norvegicus* has been well described by Lataste, from whose account the following particulars are largely drawn. They are nocturnal and omnivorous; lying in the nest curled up, the head on chest, and sometimes vertically. They form stores of provisions in their nests, females sometimes stealing the goods of their spouses. Lataste describes it as the most intelligent rodent examined, recognising its owner, licking him and pretending to bite like a puppy; it can be trained to draw up food or drink with a chain, and to count up to four. Wild rats are difficult to tame, being very fierce and intractable, unless taken very young. They are variable in individual character though usually friendly to each other, unless their sense of property be violated. They are prudent without being cowardly, and are much superior in brain to either Black or Water Rats. Although so big and heavy they are still very agile, and Lataste has killed them on the summits of the highest Palms. They swim habitually, although their aquatic powers are very inferior to those of the Water Rat. They are "hard" rats—a fall of 2 metres causing no injury. They never beat with the feet like Gerbillines, but utter cries when battling or coupling; Lataste describes the cry of grief as *sec et désagré-able.* The rut lasts only a few hours, and they are more violent in coupling than are tame mice. Gestation lasts twenty-two days, and is apparently unaffected by lactation. A few days before the end of gestation the female prepares a new nest for her family, and later she behaves as an excellent mother. The male kills and devours strange young, but respects those of a female with whom he has coupled; these he regards with seeming indifference—perhaps only on account of the maternal jealousy, for he has been known to help in transporting them when occasion required.

Lataste (373-375) describes the post-natal development. From his account it would appear that at the sixth day the pink colour of the young rat changes, indicating the development of hair. On the tenth day the back is white and covered with fine hairs of 1 mm. in length; at the fourteenth day the eyes open, and on the sixteenth day the perforation of the outer ear appears. On the seventeenth or eighteenth day

the young commence to leave the nest and eat—they are very lively. At the twenty-third day their white coat begins to attain the yellowish tints of the adults; they incessantly run, jump, and climb. By the twenty-sixth day, and sometimes even by the twenty-first or twenty-second day, they can leave their mother, but if with her they may suckle to the twenty-eighth day. The young have extraordinary vitality: one—only two days old—lived after forty-eight hours' exposure in September to the external air on a metal plate (Lataste, 344 and 374).

Rats have a considerable development of voice, frequently squeaking loudly; Johnston (240) describes one as uttering a thin metallic "skikking" sound when angry, or a grunting, murmuring noise when amorous.

Genus MUS.

1758. Mus, C. Linnæus, *Syst. Nat.*, 10th ed., i., 59; genotype, by tautonymy, *Mus musculus* (G. S. Miller, *Proc. Biol. Soc.*, Washington, xxiii., 19th April 1911, 59); in part of most authors.

1814. Musculus, Rafinesque-Schmaltz, *Précis des Découv. et Travaux Somiologiques*, 13; a substitute for *Mus.*

1837. Leggada, J. E. Gray, *Charlesworth's Mag. Nat. Hist.*, i., 586; genus for *L. booduga*, Gray.

1842. Micromys, Lesson, *Nouveau Tableau, Mamm.*, 139.

1845. Drymomys, Tschudi, *Fauna Peruana*, 178; based on *D. parvulus*, Tschudi = *Mus musculus*, Linnæus (see Thomas in Palmer, *Index Gen. Mamm.*, 246, 1904).

1876. Nannomys, W. Peters, *Monatsber. k. preuss. Akad. Wiss.*, Berlin, 480; based on *N. setulosus*, Peters.

1881. Acromys, E. L. Trouessart, *Bull. Soc. d'Études Sci. d'Angers*, x., 133; a synonym of *Drymomys*, Tschudi.

1896. Pseudoconomys, Rhoads, *Proc. Acad. Nat. Sci.*, Philadelphia, 531; subgenus based on *Mus* (*Pseudoconomys*) *proconodon*, Rhoads, from Western Somaliland.

1900. Dryomys, Philippi, *An. Mus. Nac. de Chile*, xiv., 20; a modification of *Drymomys*, Tschudi.

As now defined, the genus *Mus* is restricted to the House Mice and their allies; these, according to Miller, comprise about twenty-five distinct forms, of which seven are represented in western Europe.

This is a perfectly natural group enjoying a wide natural

distribution in southern Asia and in Africa, and having no near relationship with any other genus, except the Indian *Leggadilla*, which may be regarded as an offshoot. The genus betrays a high degree of specialisation, and as regards its dental characters it undoubtedly stands on a loftier plane than does any of the other members of the sub-family dealt with in this work.

Externally this genus does not differ noticeably from *Epimys*, but all the known species of *Mus* are of small size. The females have ten mammæ, arranged in three pectoral and two inguinal pairs.

In the **skull** the brain-case is rather small and depressed; there are no interorbital beads (present in *Leggadilla*), and the temporal ridges of the brain-case are very feebly developed; the zygomatic arches are relatively strong, particularly as regards their anterior maxillary portions, and there is a small peg-like process on the outer side of each maxilla below and just in front of the lower zygomatic root, which serves for the attachment of the tendon of the anterior part of the *masseter lateralis* muscle.

In the **dentition** the upper incisors are strongly curved, terminating behind in the maxilla between m^1 and the maxillo-premaxillary suture. The disc of wear is peculiar, there being a well-marked notch on the outer side just behind the junction of the white dentine with the yellow enamel. Winge explains this feature by supposing the dentine to be harder at the postero-external corner of the tooth than elsewhere; Miller, on the other hand, attributes it to the angle at which the teeth are set. We are not able to find any appreciable difference between *Mus* and *Epimys* as regards the "set" of the incisors, and would attribute the notch rather to the increased strength and peculiar mode of action of the *masseteres laterales* muscles, which have induced several much greater modifications in the structure of the cheek-teeth as well as in the skull itself.

The lower incisors terminate behind, near the bases of the condylar processes, their ends producing rather well-marked humps on the outer surfaces of the mandible.

Cheek-teeth (Pl. XXVIII., Fig. 10):—In this genus $m\frac{1}{1}$ are relatively large, being as long as or longer than $m\frac{2-3}{2-3}$

together. The median tubercles, x, y, and z are very largely developed. In m^1 the laminæ are conspicuously bowed, cusp x' lying distinctly behind x and in line with cusp y, cusp 6 being similarly in line with z; cusps 1, 4, and 5 are large, and clearly separated from the median tubercles; and there is no trace of either cusps 3 or 7. In m^2 cusps 4 and 5 are more reduced than in m^1, being more intimately connected with cusps y and z than in the latter tooth; cusp 1 is represented solely by a minute vestige at the base of the crown, or it may be wholly lacking; cusps x' and 6 are largely developed, the latter being in line with z as in m^1. The last molar above is very small, and consists of a large cusp x' and a postero-external tubercle, which appears to be a compound of cusp y and other elements. In some species m^3 consists of one tubercle only. In the lower molars the median tubercles y and z are so greatly enlarged that all trace of the primitive outer row of cusps (6, 7, and n) is obliterated. In m_1 cusp z' is relatively small, and there is no trace of an anterior median "accessory" tubercle; the posterior "accessory" (cusp 1) is well developed in this tooth and in m_2; m_3 consists of three cusps, viz., z and 5 in front, and a tubercle compounded of y and 4 behind.

The relatively large size of $m\frac{1}{1}$ in the genus appears to be a consequence of the increased strength of the masseter muscles; the anterior tooth is most favourably placed dynamically, and it therefore takes a larger share of the work of mastication. The hinder teeth $m\frac{2-3}{2-3}$ have become of less functional importance; they are therefore reduced in size, and $m\frac{3}{3}$ tend to disappear. In South American specimens the latter teeth are frequently lacking, either wholly or from one or the other jaw (see p. 649 below).

Nothing is definitely known of the **geological history** of this genus. It has been recorded from the British Pleistocene on several occasions; whilst most of these records seem to have been based on error, it is just possible that one or two of them may be well-founded.

THE HOUSE MOUSE.

MUS MUSCULUS, Linnæus.

1758. [MUS] MUSCULUS, C. Linnæus, *Syst. Nat.*, 1, 10th ed., 62; described from Upsala, Sweden; of most subsequent authors.

1772. MUS DOMESTICUS, J. Rutty, *An Essay towards a Nat. Hist. of the County of Dublin*, i., 281.

1801. M[US] M[USCULUS] ALBUS, FLAVUS, MACULATUS, and NIGER; J. Bechstein, *Gemein. Naturgesch. Deutschlands*, ed. 2, i., 955; described from Thuringen, Germany.

1827. [MUS MUSCULUS] STRIATUS, ALBICANS, and NIVENS, Billberg, *Syn. Fauna Scand.*, 6; described from Skåne, Sweden.

1867. [MUS MUSCULUS] HELVOLUS, VARIUS, and CINEREO-MACULATUS, L. Fitzinger, *Sitzungsber. kais. Akad. Wiss. Wien.*, *math.-nat. Cl.*, lvi., Abt. i., 70; *helvolus*, described from Hungary, *varius* and *cinereo-maculatus* from Europe.

1869. MUS POSCHIAVINUS, V. Fatio, *Faun. Vert. Suisse*, i., 207; described from Poschiavo, Grisons, Switzerland; as sub-species, Trouessart.

1872. MUS MUSCULUS, var. FLAVESCENS, Fischer, *Zool. Garten*, xiii., 223; described from Berlin, Germany.

1907. MUS NUDOPLICATUS, Campbell, *Zoologist*, 1; described from living specimens received from Australia.

1912. MUS MUSCULUS MUSCULUS, G. S. Miller, *Catalogue Mamm. West Europe*, 871.

Die Hausmaus of the Germans; *la souris* of the French.

The **synonymy** given above has reference only to the House Mouse in Europe; many other names, based upon material collected in the East or in America, have been applied to this animal, but it is not necessary to deal with them here.

The House Mouse is "*Mus domesticus*" in Albertus Magnus (*de Anim.*, xxii., fol. 182), Gesner (*de Quad.*, 1551), Jonston (*Quad.*, 115, t. 66, 1657), and Merrett (*Pinax*, 167, 1667); "*Mus domesticus minor*" in Aldrovandus (*Digit.*, 417); "*Mus domesticus vulgaris seu minor*" in Sibbald (*Scot.*, 12, 1684) and Ray (*Syn. Quad.*, 218, 1693); "*Mus minor*" in Klein (*Quad. disp.*, 57); it is "*Sorex domesticus*" in Charleton (*Exercit.*, 25, 1677), and "*Sorex*" in Brisson (*Reg. Quad.*, 1762, 119), and Gronovius (*Zoophy.*, 1, 4, n. 19).

Terminology:—Variants of the word "mouse" (derived from the Sanskrit *mūš* and the Greek *μῦς*) are common to all the Teutonic and Indo-Germanic languages, and were used, like the Latin *sorex* and the Celtic *luch*, indiscriminately for all small, mouse-like rodents and insectivores. The House Mouse being the most familiar of such creatures, the word was at an early date specially applied to this species, without, however, losing its more general significance. The earliest instances of such special usage of "*mus*" and "*mys*" in English, cited in the *N.E. Dictionary*, are in King Ælfred, *Boeth.*, xvi., 2 (about 888), and

in *Lamb. Hom.*, 53 (about 1175); in the latter it is stated that "*purh y^e sweote smel of y^e chese he bicherred monie mus to y^e stoke.*" Derivatives of "*sorex*," as the French *souris*, similarly acquired a secondary, restricted meaning, and came to denote the present species. In ancient times, as mentioned on p. 578 above, the word "*rat*" also was perhaps used for the House Mouse in western Europe.

The mouse of course figures in many familiar expressions of ancient origin; thus, "drunk as a dreynt (= drowned) mouse" is met with about 1310 (Wright, *Lyric P.*, xxxix., iii.) and in Chaucer (*Wife's Prol.*, 246); "quiet as a mouse" starts in 1599 in Porter (*Angry Women*, 184, 71), and "wrecched mouses herte" occurs in Chaucer (*Troilus and Creseide*, iii., 736). *Mouse-traps* are mentioned in *circa* 1475—*Cath. Angl.*, 245/1 (MS. addit.).

In technical writings this species is usually the "Mouse" or "Common Mouse," as in Pennant (*Brit. Zool.*, i., 108, ed. 1776; *Hist. Quad.*, ed. 3, ii., 184). "Domestic Mouse" appears in Macgillivray (250). "House Mouse" was apparently first used technically by Jenyns (*Man.*, 31, 1835), and is to be preferred to "Common Mouse," generally used in books, since our dwellings form the chief station of the species in Britain, while out of doors its numbers are far inferior to those of the Field Mouse.

Local names (non-Celtic):—"Rick Mouse" and "Barn Mouse" (the latter in Scotland) are names used for some outdoor mice, "larger and darker than the House Mouse" (Tomes in Bell, ed. 2, 300).

(Celtic):—In the Celtic languages it is called simply "*luch*" (Scotch and Irish Gaelic) or "*llygoden*" (Welsh)—these names being used with or without distinctive epithets for most other "mice" as well.

History, distribution, and status:—Although in all probability the House Mouse is of Asiatic origin, we possess no decisive or very clear evidence on this point. Its arrival in Europe must date from a very remote time, for the animal was well known to the ancients: it is definitely referred to by Aristotle (*Hist. Anim.*, i., c. 2, 15) and Pliny (*Hist. Nat.*, viii., c. 56); numerous references to it by Greek writers are quoted by Rolleston (*Journ. Anat. and Phys.*, 1868, 47). Early mediæval writers on natural history, as Albertus Magnus, had exact knowledge of it, and many references to it are of course to be found in our own literature; some of these are quoted above under Terminology, and in the article on the Black Rat (p. 578). Donovan (xxxviii.) thought it native, because it is mentioned in the *Leges Wallicæ* more than ten centuries ago.

It arrived in North America shortly after the first settlement of Europeans there, and is now distributed in all the settled parts of the New World; being scarce, however, in the extreme north, because it does not always survive the winters (Lantz, *op. cit.*, p. 11).

This species owes its present almost universal distribution to its success as an invader and colonist of human dwellings and store-places, and to subsequent accidental transport with human commerce. In cool climates, although often found living out of doors, it is rarely met with far from houses or other scenes of human activity. But in countries where the climate is suitable and food readily obtainable, as in many of the warmer parts of America, it has resumed a free or natural station, and competes successfully with the indigenous rodents. In such situations it, like other murines, shows an inherent plasticity, enabling it to develop races modified in one way or another to meet the peculiar requirements of a foreign environment.

Distribution in time:—The remains of "mice" recorded by Buckland (*Rel. Diluv.*, 19, 265, pl. xi., figs. 7-9) from the Kirkdale Cave were probably remains of *Apodemus;* the figured jaw agrees in size with that of the Field Mouse, and the rather inaccurate drawing of the cheek-teeth might represent teeth of that species quite as well as those of the House Mouse. Owen (*Brit. Foss. Mamm.*, 209, fig. 79) also figures a jaw from Kirkdale; this drawing, as regards the teeth and form of the jaw, agrees better with the House Mouse, although the size is rather large. The species is listed from Kent's Cavern and the Durdham Down Cave, by Morris (*Cat. Brit. Foss.*, 1854, 360) and Boyd Dawkins (*Q.J.G.S.*, xxv., 198, 1869); it has also been doubtfully recorded from the Pleistocene of Copford by R. Bell (*Proc. Geol. Assoc.*, ii., 217, 1871). It has been stated to occur in the Pleistocene deposits of the Thames valley (see Lydekker, 189). Although we have had the advantage of studying a far greater number of British fossil mouse remains than has any other observer, we have never met with the slightest trace of this species among them; we are, therefore, inclined to doubt the identifications in some cases, and to think in others that the remains were comparatively recent introductions in the deposits whence they have been recorded.

Description:—The House Mouse is a slenderly built, rather sharp-faced murine of medium size (head and body, 75 to 100 mm.; hind foot, 17 to 19·4; condylo-basal length of skull, 19·8 to 22·4 mm.), with the tail about as long or longer than the head and body, clad with soft fur, and usually of a brownish-grey colour.

The **eyes** are small, and somewhat protruding, although much less prominent than in the Field Mouse. The broadly ovate **ears** are of moderate size, their length being about half that of the head, and they cover the eyes when laid forwards; save for the naked internal basal portions, they are thinly clothed within and without, with short and fine hairs; in each the meatal valve is represented merely by a low ridge placed just behind the meatus.

In each **hand** the thumb is a vestigial tubercle, scarcely exceeding

one of the palmar pads in size, and bearing a small flattened nail; digit 3 is the longest finger, digit 4 being very slightly shorter; digit 2 is slightly shorter than digit 4, and digit 5 reaches a little beyond the base of digit 4. The five palmar tubercles are small, occupying less than half of the surface of the palm; the three anterior are small and round, the external one having a small additional free tubercle by its outer side at the base of digit 5; the posterior pads are larger and oval. Between the pads the skin is irregularly wrinkled and granular; the ventral surfaces of the digits have annular scales which tend to be interrupted in the middle.

The **feet** compared with those of the Field Mouse are shorter and broader, and each has the usual six pads. The latter are relatively small, and widely spaced, of oval or rounded form, and differ but little from each other in size—the two anterior being slightly the largest, the postero-external slightly the smallest. In addition, a little free supplementary tubercle is developed to the outer side of the pad at the base of digit 5, and there is a similar tubercle to the inner side of the pad, at the base of the hallux. The skin between the pads is wrinkled, but smooth towards the heel. The hinder part of the sole is hairy along the edges, and solitary hairs are scattered between the pads. Digits 2, 3, and 4 are the longest, 2 and 4 being slightly shorter than 3; digit 5 reaches a little beyond the base of digit 4, and digit 1 extends as far as the base of digit 2. Both the fingers and toes (including the hallux) are armed with small, simple, curved claws, those of the toes being slightly the longer.

The **tail** is usually about as long as, or a little longer than, the head and body; it is finely annulated with about 180 scaly rings, the boundaries of the individual scales being somewhat indefinite; it is clothed with numerous short, stiff hairs, each equalling in length the width of about two and a half annulations; the hairs do not, however, conceal the rings, and they do not form a terminal pencil.

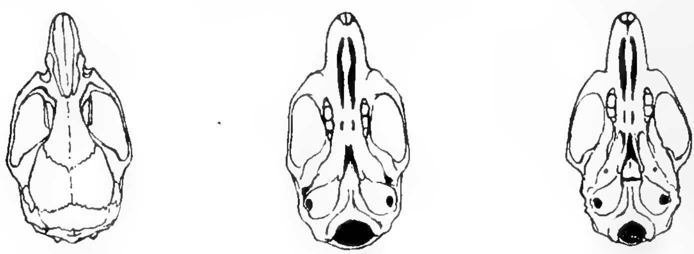
The **fur** is soft throughout, longer, and denser on the back; shorter, thinner, and rather closely adpressed on the belly; grooved bristles occur as in the rats, but they are so slender as to produce no sensible effect upon the quality of the pelage. The microscopic structure of the hair is described below under *Pigmentation and Inheritance.*

Colour:—The general colour of the upper parts is a dusky grey, irregularly darkened with slate and black along the middle of the back, and paling gradually to ashy grey on the flanks and belly. The hairs have slaty bases, appearing on the surface in the region of the chin and throat, and dusky tips; their subterminal bands are yellow, and these produce a more or less well-marked tinge of yellow above and below. The ears are of a dull brownish colour, their antero-external edges being usually darker than the other parts. The feet are dusky above,

and do not afford any noticeable contrast with the general tint of the back. The tail is usually dull brown, both above and below, but sometimes the under surface is slightly the paler.

The **young** in first pelage hardly differ from the adults in general colour; their coat is a little softer and closer, consisting chiefly of the woolly underfur.

The **skull** (Fig. 93) compared with that of the Field Mouse is disproportionately small and peculiarly flattened. In correlation with the small size and weight of the brain (see p. 566 above), the broadly ovate brain-case is depressed, its depth being relatively little greater than that of the rostrum. The interparietal is large and rectangular, and it belongs wholly to the occipital region, the lambdoidal crest and suture passing in front of, instead of behind it, as in *A. sylvaticus*. The interorbital region is broader than the rostrum; its edges are square and not beaded, and the temporal crests, which are their backward continuations on the sides of the brain-case, are very feebly developed. The



(1) (2) (3)

FIG. 93.—SKULLS OF *Mus musculus* (1) dorsal, (2) ventral; AND *Mus muralis* (3) ventral; × 1½.

zygomatic arches are relatively strong, and their greatest breadth usually falls just in front of the glenoid articulations; the vertical anterior border of the masseteric plate is situated distinctly in advance of the roof of the infra-orbital canal, and at its base there is a quite small, but prominent peg-like process, from which the tendon of the anterior part of the masseter muscle takes its origin. The incisive foramina are greatly narrowed behind; they are of remarkable length, and terminate posteriorly about opposite the middle of m^1. As in *Micromys*, the palatal shelf extends backwards behind the tooth-rows for a short distance; in this region it shows also a slight median ridge, which is frequently channelled by a weak longitudinal ventral groove. The mesopterygoid fossa is of moderate length, wider behind than in front, where it terminates squarely. The pterygoids are straight, and their hamular processes barely meet the moderately large auditory bullæ. The nasals extend forwards but little in advance of the front faces of the incisors.

The **mandible** is slightly shorter and deeper relatively than in the

Field Mouse; the strongly recurved coronoid processes rise slightly above the level of the condyles.

The **teeth** have been described above under the genus.

Local variation:—The yellow subterminal bands of the longer hairs are usually better developed in outdoor House Mice, which, therefore, have a more sandy appearance than those generally caught in houses. This fact has long been known, as, to Macgillivray, who states (251) that "individuals obtained in the fields are sometimes almost as beautifully coloured as the Wood Mouse, there being much yellowish-brown on their upper parts, and their lower being of a dull cream-colour"; and to Jenyns, who adds (*Man.*, p. 32) that they "sometimes attain a larger size, measuring nearly four inches in length."

The mice described by Jameson (*Journ. Linn. Soc.*, xxvi., 1898, p. 465) from the sandhills of the North Bull, Dublin Bay, though differing among themselves, are characterised by their very light colour, and may be regarded as representing the extreme phase of the yellow outdoor coloration; these mice live on a barren sandy waste, where they are exposed only to the attacks of enemies hunting by sight alone; therefore, as suggested by Jameson, it is not unlikely that natural selection has played and is playing an important part in the elimination of the darker individuals of the colony.

Adams[1] (*MS.*) has caught tawny bellied House Mice in Surrey and Sussex; these were taken usually in cornfields and hedge-banks—often 300 or 400 yards from any building, sometimes in ricks at threshing, and once or twice in country houses. He notes that the tails were often relatively longer than in indoor House Mice. A few years ago W. Evans observed that the House Mice living out of doors on the Isle of May (Firth of Forth) were lighter in colour than ordinary indoor examples; he sent one of these to Barrett-Hamilton. It seems probable that the original colour of wild *M. musculus* was some shade of yellow or tawny; and that in this case, as Adams suggests, the tawny hue of present outdoor families may be explained either as a reversion to type, if such families have descended from a domestic stock, or as a retention of the ancestral coloration, if they have always been feral. In either case the difference between the indoor and outdoor coloration, whatever its "protective" value may be, is probably to be explained as a result of the wide difference in the light intensities to which the two stocks are respectively exposed.

Kinnear (*Ann. Scott. Nat. Hist.*, 1906, 65) describes the House Mice of **Fair Isle** as being rather larger and more tawny in colour than main-

[1] Adams (*MS.*) "noticed very markedly in the sunny summer of 1911, that the coats of the Common Shrew were lighter in colour than usual. There was much more albinism in ears than usual—about 25 per cent. had white ears in that year, whereas about 4 per cent. is the normal condition."

land mice; they are said to be very numerous among the crofts, but after the corn is cut they betake themselves to the houses.

The House Mice from Braescleit and Barvas, western **Lewis**, differ in no way from ordinary *musculus* (W. Eagle Clarke, *Ann. Scott. Nat. Hist.*, 1908, 198; Hinton and Hony, *The Scottish Naturalist*, 1916, 221). From fields at the Butt, or northern extremity, of Lewis, Eagle Clarke, however, obtained specimens which approach *muralis* in their large size, but do not differ from *musculus* in coloration or in skull structure.

On **North Uist** ordinary House Mice, and others which are practically identical with *muralis* in size and colour, though slightly paler below, occur quite commonly in the houses at Lochmaddy. Intermediates between the two forms have not been observed, and although the only but imperfect skull seen seems to agree better in form with that of *musculus* than with that of *muralis*, it is not impossible that the variety may be a second form of the latter species (Eagle Clarke, *op. cit.*).

A youngish female from **Islay** has the whole ventral surface of a beautiful clear white, separated by sharp lines of demarcation from the flanks, which are but slightly lighter than the back, the general dorsal colour approaching that of *Apodemus* (Hinton, *Ann. Mag. Nat. Hist.*, July 1914, 130, and June 1915, 583). Specimens from **Skye**, and a male from **Tiree** (*Proc. Zool. Soc.*, 1913, 835) trapped in sand-hills, represent the yellowish outdoor form, while one obtained by Mr Kinnear in **Barra**, from a hole in a field, is of normal indoor appearance.

Specimens obtained for Ogilvie-Grant from Hermaness Hill, **North Unst**, **Shetland**, in the autumn of 1914, are remarkable merely for their relatively stout tails.

Exceptional variation:—Quite apart from the well-known differences in pattern and colour presented by the tame "fancy" breeds, the House Mouse shows many individual or family variations, particularly in its coloration and pelage. Such variations have formed the bases of most of the specific or sub-specific names enumerated in the synonymy above.

True albinos, wholly white or cream-coloured with pink eyes, partial albinos, white specimens with dark spots, dark specimens with light spots, and melanistic examples, are not rare. Fatio's *M. poschiavinus* was based, with much hesitation, on a Swiss melanic race.

Tomes (in Bell, ed. ii., 296) describes a great number "killed in a wheat-rick at Welford-on-Avon, which were of a light grey colour, without the least mixture of brown," and Collett (165) speaks of a similar variety in Norway. In another rick at Welford Hill, Tomes found all the mice to be "of an unusually dark colour, especially along the dorsal line, which was nearly black"; this latter form is apparently that to which the names "Rick Mouse" and "Barn Mouse" are applied (Tomes, *op. cit.*, 300), and which occasionally, though not always, attains an unusually large size.

Several specimens of a pale buff or cream variety were sent to W. Evans from Lyne, Peebles, where they occurred in some abundance, in April 1890.

Varieties with long, black, silk-like hair (W. P. Cocks, *Rep. R. Cornwall Polytech. Soc.*, 1852, 59); naked, with corrugated skin (a few whiskers present), and producing similar young (Bateson, *Variation*, 56); partially naked and smooth-skinned (?disease or parasites; Gordon, *Zoologist*, 1850, 2763) have been recorded. Cocks (*Bucks* and *Zoologist*, 1903, 420) mentions an epidemic of blind and partially blind House Mice captured during a succession of years in one locality.

Pigmentation and inheritance:—When examined microscopically, under a low power, the hairs of the back are seen to be of three kinds, although all have slender bases and fine distal, terminal points. Some (Fig. 94) are short and fine, constituting the underfur. Others are of medium length, flattened and broadly expanded centrally; these apparently correspond with the spines found in the fur of rats. Lastly, many are very long and show two or three expanded tracts alternating with contracted portions (Fig. 94)[1]; the terminal expansion of these hairs is usually bright yellow in colour, but the fine tips together with the lower portions are black or dusky. To these longer hairs the general colour is due. The belly is clothed only with the short hairs of the underfur.

The minute structure of the hairs is, as in many other rodents, of a remarkably complex type. Each hair consists as usual of an outer sheath or cortex of kerotin investing a central medullary cavity; when highly magnified, the latter is seen to be divided into compartments by slender bridges of kerotin. At the base of a hair the bridges are transverse and the compartments simple; but in the broader parts, and particularly in the "spines," the bridges acquire an oblique direction, and send forwards and backwards outgrowths of kerotin which join similar processes from the contiguous bridges; by this means in such places the transverse medullary compartments are divided into two, three, four, or five separate secondary chambers (Fig. 94). The number of secondary chambers to a transverse compartment increases as the hair expands, and diminishes again as it tapers distally.[2]

[1] Douglas English describes and figures similar alternately contracted and expanded hairs in the Shrew (*Some Smaller British Mammals*, 66).

[2] This structure attracted attention in the earliest days of microscopy. Thus Shaw (*General Zoology*, ii., Pt. 1, 57, 1801) describes the hairs as "appearing internally divided into a kind of transverse partitions, as if by the continuation of a spiral fibre." He further cites Derham (1657-1735), who, in his *Physico-Theology*, conceived that this mechanism of a spiral fibre may serve for the "gentle evacuation of some humour out of the body," and added that "perhaps the hair serves as well for the insensible perspiration of hairy animals as to fence against cold and wet."

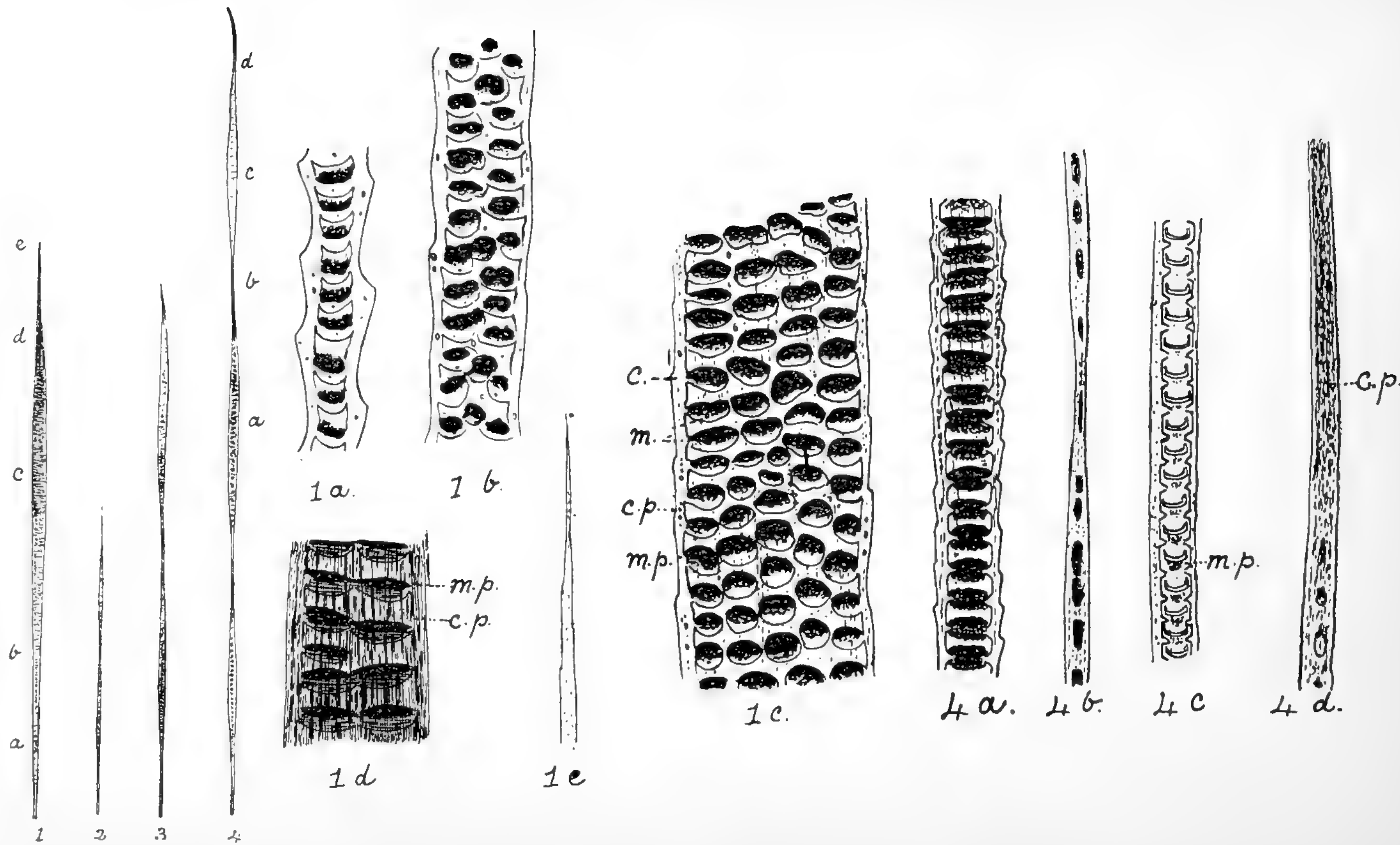


FIG. 94.—HAIRS FROM BACK OF HOUSE MOUSE: (1) Spine; (2) short hair; (3) long hair, with one central contraction; (4) long hair, with two central contractions (enlarged, width exaggerated). 1*a-e* and 4*a-d*, camera lucida drawings of the correspondingly lettered portions of the hairs shown in Figs. (1) and (4); as printed, the magnification equals 570 diameters, but the structure represented is that seen with a magnification of 960 diameters. In these drawings, *c*=cortex; *m*=medullary cells; *c.p*=cortical pigment; *m.p*=medullary pigment.

Some of the medullary chambers contain air only, but in the majority, pigment granules occur as well. The pigment present varies in amount, from a few isolated granules to thick clusters adhering to one or other of the walls of the medullary chamber, and almost filling its space. The medullary pigment of the "spines" and of the lower parts of the other hairs is usually black and opaque; but a few granules are dark brown, and to some extent translucent. The base of the hair and many tracts of the cortex are clear and devoid of pigment. In other places, as at the expansions, and especially towards the distal contractions, the cortex contains many scattered pigment granules, which are occasionally arranged in two or three little longitudinal and closely approximated rows. The cortical pigment of the longer hairs is usually dark brown in their lower portions, but at these deep levels a few yellowish granules may occasionally be seen.[1]

As mentioned above, the terminal segment of a long hair is usually yellow except towards its tip, where the medullary pigment is absent and the abundant dark cortical pigment gives a dusky hue. On carefully examining such a hair segment, it is frequently possible to observe, firstly, that the medullary pigment is rather darker (brownish) proximally, but becomes gradually lighter to golden or translucent yellow distally; and secondly, that the cortical pigment shows a similar transition at the corresponding levels.

Colour is now regarded by many[2] as resulting from the oxidation of a chromogen by the action of a ferment; the tint produced depending partly upon the nature of the chromogen and partly upon the degree to which it is oxidised. The results of our work, confined as it has been to a careful microscopic examination of the hairs of mice and many other mammals, lead us to think that the transition from black pigment through brown to yellow is a gradual one, and that it may well be the result of progressive oxidation. The gaseous contents of the medullary chambers perhaps play a part in this process, and the dark hue of the cortical pigment of the hair tips may be due to the fact that the medullary space dies out before reaching the hair tip.

The local attenuations of the longer dorsal hairs of the House Mouse probably assist in the coat change. The distal yellow segment of the hair breaks off in due course at the contraction next below it; this contracted part becomes the new hair tip, and as growth pushes it

[1] For another account of structure of hairs and distribution of pigment in House Mouse, see Durham, in Bateson, *Proc. Zool. Soc.*, 1903, ii., 72.

[2] For further information on the chemistry of colour, see—Cuénot, *Arch. Zool. Exper. et Gén.*, *Notes et Revue*, 1, xxxiii.; Durham, *Proc. Roy. Soc.*, 74, 310, 1904, and *Journ. Physiol.*, 35, May 1907; Mudge, *Journ. Physiol.*, 38, March and Oct. 1909, and *Nature*, 14th April 1910, 18; Sollas, *Nature*, 24th March 1910, 96; Forbes, *ibid.*, 21st April 1910, 217; Wheldale, *Prog. Rei Botanicæ*, iii., 457, 1910; Onslow, *Proc. Roy. Soc.*, B 1915, 36.

up the dark pigments of its segment in turn gradually oxidise and become yellow. In some "voles," e.g., *Microtus orcadensis* (see p. 458 above), a similar process appears to take place occasionally.

Extensive researches upon the **inheritance** of the coloration, coat pattern, and of some physical defects in the House Mouse, have been made by the Mendelians. The literature relating to this work has become quite voluminous, and no more than a mere outline of the broader results can be attempted here. The experiments have mostly been made with tame "fancy" mice, but these have been crossed from time to time with wild animals. The various conditions investigated have been proved for the most part to depend upon the presence or absence of certain definite factors, and to obey Mendel's law in inheritance. In the following paragraphs the capital initial signifies the presence of a factor as opposed to its absence, denoted by a small initial; in general, X is dominant, x recessive.

As regards *pigmentation*, a considerable number of factors appear to be involved. Colour is produced by a special factor, C, and if this be absent (c) the mouse will be an albino even if it carry all of the other pigment factors. The depth of the coloration depends upon another factor, D; when this is present with C, the pigment granules are developed in full number, and the colour is intense or saturate; in its absence (d), there are fewer granules and the colour is dilute. The precise hue of the mouse depends upon a large number of factors, known as "colour determiners"; these determiners stand apparently in a certain definite relation to each other. When all the normal determiners are present, together with C and D, the animal is in appearance an ordinary wild House Mouse, grey or "agouti" in colour. Should the grey determiner (G)[1] be lacking, and the black (B) and chocolate (Ch) determiners be both present, the mouse will be black—the determiner B masking the determiner Ch. To be chocolate in colour the mouse must not only carry Ch, but it must lack the determiners G and B. Grey cannot, however, be called dominant to black, because these factors belong to different allelomorphic pairs, and Bateson, therefore, introduced the terms "*epistatic*" and "*hypostatic*" to express the relationship of the different colours; thus, in relation to black (B), grey (G) is epistatic, while chocolate (Ch) is hypostatic.

The combined researches of Cuénot, Durham, Castle and Little, Hagedoorn, and others, have shown that yellow mice belong to two entirely distinct groups, namely:—(1) that in which yellow arises

[1] Strictly, there is no "grey determiner" at all, there being no grey pigment in mice. The grey colour is produced by "barring and ticking," *i.e.*, by the orderly arrangement of the three pigments, black, brown, and yellow, in each hair in definite bands of restricted extent. This arrangement is brought about, according to the Mendelians, by the presence of a special factor (or pair of factors, according to Hagedoorn) called the "grey determiner" above.

by means of the suppression of the chocolate determiner (*Ch*); and (2) that in which the yellow colour is due to the presence of a definite yellow determiner.

Yellow mice of the first type were studied by Hagedoorn, who proved that all mice lacking the chocolate determiner are some shade of yellow; that in such mice, if the determiners for grey (*G*) and black (*B*) are present, the mouse appears as a "yellow agouti," while it is "tortoise" if the black determiner alone is present. This group is apparently strictly comparable with the yellow forms of rabbits and cavies, in both of which, as here also, yellow shows itself to be hypostatic to black and grey. Mice homozygous for *ch* are readily produced when once a culture lacking *Ch* has been obtained.

Much greater interest attaches to the second group of yellow mice. These were first studied by Cuénot, and afterwards by Miss Durham, Castle and Little, and still more recently by Hagedoorn. Here the yellow colour is due to a yellow determiner, called *I* by Hagedoorn, which shows itself to be epistatic to grey and black, and which is quite unknown in wild House Mice. No one has so far succeeded in obtaining homozygous yellow (*II*) mice, although large numbers have been bred; such yellows are always heterozygous (*Ii*), and when mated together, as Castle and Little have shown, they produce yellow and non-yellow young in the ratio 2 : 1 instead of 3 : 1, as would be expected by the application of ordinary Mendelian principles. According to Castle and Little it would seem that a whole class, viz., that of the homozygous yellows (*II*), is absent from the progeny; not because yellow ova fail to be fertilised by yellow spermatozoa in due numbers, but because the homozygous germs so produced perish soon after they are formed, having apparently some physiological inability to develop further. Cuénot, Miss Durham, and Castle and Little all found evidence (smaller litters and a greater liability to sterility) of diminished fertility in these yellow mice, while the frequent tendency of such animals to become excessively fat is well known. These facts afford strong grounds for the presumption that the introduction of the yellow determiner (*I*) gravely deranges the physiological equilibrium of the individuals carrying it. The question as to how this strange determiner has been introduced is quite unsettled; the most plausible explanation yet offered is that it has been brought into the breeds showing it by means of hybridisation with some other species at present not identified. Bateson, on the ground of a claim by a well-known breeder of mice to have made such a cross, thought that there might have been a cross with the Field Mouse. However improbable this view may be, it cannot be dismissed without further experiment, because, apart from the old statement made by Melchior, cited on p. 552 above, Hagedoorn states that, although the species do not mate together

naturally, he succeeded in impregnating, by artificial insemination, a female *M. musculus* by a male *Apodemus sylvaticus;* unfortunately, the mouse either aborted or else ate her young. As Hagedoorn points out, it is quite possible that if the determiner *I* came originally from another species, that other species may not have been a yellow animal at all. We are inclined to think that in connection with this problem Mendelians might profitably try to cross *M. musculus* with *spicilegus*, or one of the other truly wild species of *Mus*.

Albinism results either from the absence of the colour factor (*C*), or from the absence of all the colour determiners. Albinos lacking *C* may lack all the colour determiners also, or they may carry certain of or all the colour determiners, either in a dilute or a saturated condition. Albino mice are thus of many distinct kinds, although these kinds cannot usually be distinguished by inspection; appropriate breeding-tests, however, reveal the constitutional differences clearly.

The pied types of mice are less definite than those of rabbits and rats, but their coat-pattern is also known to follow Mendel's law in inheritance. Pied mice frequently behave as recessives to whole or self-coloured animals, and Cuénot was led to conclude that the pied forms with more white are recessive to those with less. Miss Durham, however, found that certain pied mice behaved as dominants when crossed with self-coloured mice, being in this respect analogous to the "English patterned" rabbits. This occurrence of both dominant and recessive piedness in tame House Mice affords an interesting parallel to the similar occurrence of dominant and recessive yellow mice discussed above.

Although further remarks upon coloration and coat-pattern, from a more general point of view, must be reserved for the introduction to this work, it is necessary to state here that Mendelian factors are by no means simple things as a rule. Each factor is perhaps to be regarded as the physiological expression of the sum of a multitude of characters assembled in a definite combination. When one or more of these characters drop out of, or others enter the complex, the latter is disturbed, and by readjustment a new combination, more or less different from its parent, is formed; this new combination betrays itself by producing a more or less well-marked modification of colour or pattern; and thus we become aware of the fact that "factor *X*" or "colour determiner *Y*" are mosaics, and not units.[1]

[1] Reference may be made to the following literature for details and further references:—Bateson, *Proc. Zool. Soc.*, 1903, ii., 71; Mendel's *Principles of Heredity*, Cambridge, 1909; Cuénot, *Arch. Zool. Expér. et Gén. Notes et Rev.*, 1902, xxvii.; 1903, xxxiii.; 1904, xlv.; 1905, cxxiii.; 1907, i.; *Bull. Mens. Réunion Biol. Nancy*, 1904, 1050; and *Brünn Verh. Naturfor. Ver.*, 49, 214; Castle and Little, *Science*, N.S., 32, 868, 1910; Darbishire, *Biometrika*, ii., 1902, 101, 165, and

Geographical variation:—Of the seven European forms of *Mus* recognised by Miller, two only are referred by him to *M. musculus*, viz.: *M. m. musculus*, described above, and *M. m. azoricus*, Schinz, inhabiting the Azores and the Mediterranean region. The latter sub-species is distinguished from the typical form by its lighter and yellower back, and its buffy grey, instead of dusky grey belly. It may be regarded merely as a phase of coloration appropriate to a sunnier climate, and the gap between it and the dusky indoor animal of northern countries is, at least, partly bridged by our more pallid outdoor individuals. Winge (*op. cit.*, 89) states that at present the wild-coloured race is the common one in Denmark; he adds that formerly the dusky indoor form has certainly been preponderant. Two insular forms, *M. muralis* and *M. fœroensis*, from St Kilda and the Færoes respectively, are accorded full specific rank by Miller; these are discussed below.

The remaining three European members of the genus are treated by Miller as sub-species of *M. spicilegus*, Petényi, described from Hungary. This species differs from *M. musculus* in its smaller size (condylo-basal length of skull rarely attaining 21; hind foot usually between 15 and 17 mm.); in having the tail nearly always noticeably shorter than the head and body, the under parts whitish and sharply contrasted with the flanks, and the notch of the upper incisor less developed. The typical form, characterised by its clear greyish-brown upper parts, ranges from the northern part of the Balkan Peninsula to the Baltic, and westwards into southern Sweden. Its representative in central and southern Spain is *M. s. hispanicus*, Miller, in which the dorsal colour is "buffy, or pale buffy grey." The third sub-species is *M. s. lusitanicus*, Miller, known only from Cintra, Portugal; in this the upper parts are brownish-grey, and show a decided tinge of russet. Both Thomas (*Zoologist*, 1896, 137), who first discovered *M. spicilegus* in Portugal and afterwards in the Balearic Islands, and Miller (*Catalogue*, 877) regard this species as truly indigenous to the Mediterranean region. It leads a perfectly wild life in fields, scrub, and open, dry forest, and it thus affords in station and coloration a close parallel to *Epimys rattus frugivorus*. It appears to be the natural representative in Europe of *M. spretus*, Lataste,[1] from North Africa; and Thomas states that "like the Mungoose and the Genet, it forms part

282, iii., 1 (Japanese Waltzing Mice crossed with European albinos); Durham, *Rep. Evol. Comm. Roy. Soc.*, iv., 41, 1908; Hagedoorn, *Univ. California Pub. Physiol.*, iii., 1909, 95; *Zeitsch. indukt. Abstammungslehre*, Berlin, 6, 1912, 97; and Little, *Washington Carnegie Inst.*, *Pub.* No. 179, 1913, 11.

[1] *Actes Soc. Linn.*, Bordeaux, 1883, 17; but later (*Cat. crit. Mamm. Tunis*, Paris, 1887, 22) Lataste himself recognised that *M. spretus* "is, perhaps, only a very aberrant variety of the House Mouse."

of the North African element in the Portuguese fauna." In the eastern Mediterranean region *M. gentilis*, Brants, and in southern Asia, *M. bactrianus*, Blyth, apparently represent the same group of wild, light-bellied House Mice.

It cannot be said that our knowledge of the status of the forms mentioned above is in a very satisfactory state. The characters by which these forms are distinguished from *M. musculus* are for the most part of trivial importance, and hardly sufficient to raise these mice above the rank of sub-species of *musculus*. The forms in question, however, seem to have found their way to Europe at very different times, by different routes, and in different ways; some, like *spicilegus*, have spread westwards and northwards naturally, while others, like *musculus*, have travelled as the constant companions of man. Moreover, it is just possible, as noticed above, that the genus was present here during part of the Pleistocene; and if this be so, either *M. muralis*, *fœroensis*, or *spicilegus*, or all three, may be the descendants of this ancient stock. For the present, therefore, pending further research upon the very difficult problems involved, it would seem better to follow the somewhat delicate classification adopted by Miller, than to group all these forms as mere sub-species of *musculus*.

A systematic study of the American colonies of *Mus* and *Epimys* might yield important information concerning the mechanics of geographical variation. The absence of native *Murinæ* from the New World eliminates one of the chief difficulties attending such research in the Old World; for, in the latter, we cannot ascertain to what extent newcomers have blended with indigenous species of these genera in any given region. J. A. Allen (*Bull. Am. Mus. Nat. Hist.*, 1894, 175; 1895, 236; 1896, 59; 1897, 35, 116, 198 (Allen and Chapman); 1899, 8; 1903, 540; 1904, 435; and 1910, 101) has given detailed descriptions of many American specimens of *Mus*. House Mice from Cajabamba, Peru, showed a strong tinge of rusty buff, and similarly coloured examples are before us from Ecuador and Cordoba, Argentina; those from Santa Marta, Colombia, were also rather more fulvous above and below than are normal specimens from the United States; those from San José, Costa Rica, were unusually pallid. In Texas and Arizona the species lives, in many places, a quite wild life, and is developing a remarkably red coloration. House Mice were found at Jalapa, Vera Cruz, inhabiting "old fields" in company with native rodents; these mice have been recognised by Allen and Chapman as forming a distinct sub-species, their *M. musculus jalapæ*, characterised by having the mid-dorsal region and tail of a uniform deep black throughout, the sides yellowish-grey, or ordinary mouse colour, the belly pale buffy grey, and the feet and ears dark brown. Similarly, dark coloured mice, perhaps belonging to the same sub-species, occur in Nicaragua. Winge

histories of very many others, which were formerly little known, have been fully elucidated, while, speaking generally, an immense increase in our knowledge on such important subjects as Migration, Distribution, Habits, Nidification, Plumages, has accrued: And lastly, a new and important branch of study has been instituted —namely, the recognition of the various Racial Forms or Subspecies exhibited by certain birds in the British Islands, on the Continent, and elsewhere.

A great advance has also been made towards a more satisfactory system of classification of the Aves—always a difficult subject—and this necessitates departures from the older views.

To bring this Standard Work thoroughly abreast of the most recent knowledge in all these departments is the object of the present work.

It should be remarked that while it is not intended to go fully into Synonomy, yet, where changes of nomenclature have been necessary in order to conform with the Law of Priority—the only method by which complete uniformity in nomenclature can ultimately be attained—the names used in the Fourth Edition of Yarrell's "British Birds" and in Saunders' "Manual," and the Trinomial Names of the British Racial Forms, and of those occurring in Britain as visitors from the Continent, will be quoted, as will also the Original Name under which the species was described.

In requesting Dr Eagle Clarke to undertake the duties of Editorship, the Publishers desire to make it known that they are acting under the advice of the late Mr Howard Saunders, who placed all his collected notes for a New Edition at Dr Eagle Clarke's disposal for this purpose. That Dr Eagle Clarke is eminently fitted for the work is well known to all who are interested in ornithological science. Through his investigations of the subject, and contributions to its literature, he has long been recognised as one of the foremost authorities on all that relates to British birds. He has studied our native birds in many portions of the British Islands, and has visited a number of bird-haunts in various parts of Europe in order to become acquainted in their Continental homes with the visitants that seek our shores.

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ILLUSTRATED BY ORIGINAL COLOURED PLATES OF EACH SPECIES SPECIALLY EXECUTED BY

MISS LILIAN MEDLAND

THE publication of Yarrell's "History of British Birds" was commenced in 1837 and completed in 1843. Its outstanding merits were at once recognised, and a Second Edition was called for in 1845, followed by a third in 1856.

From the issue of the Original Edition down to the present day, Yarrell's "History of British Birds" has generally and deservedly been regarded as the standard authority on British ornithology.

In the year 1871 a Fourth Edition was begun, under the masterly editorship of Professor Newton—the greatest British ornithologist of all time. Unfortunately Professor Newton's official engagements at the University of Cambridge only allowed him to complete the first two volumes; and in 1882 Mr Howard Saunders was selected to edit the remaining volumes, a task which he successfully accomplished to the entire satisfaction of ornithologists in 1885.

The many excellences of this last edition advanced the work more than ever in the public and in scientific favour. To its stimulating influence is to be mainly attributed the marvellous and unprecedented activity which has resulted in those extraordinary advances made in all branches of British ornithology during recent years—advances which have rendered it essential that a new work based upon this classical and comprehensive foundation should be issued.

During the period alluded to, a considerable number of new and interesting species have been added to our avifauna. The

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The English local names have been revised in part by Mr W. W. Skeat, M.A. (assisted by the late Professor W. W. Skeat), and in part by Mr C. M. Drennan, M.A. Lond., late Scholar Emm. Coll. Camb.; the Celtic and Gaelic names by Dr E. S. Quiggin, M.A., Ph.D., Fellow and Lecturer in Modern Languages and Celtic of Gonville and Caius College, Cambridge; while a list of Scottish Gaelic names has been supplied by Mr C. H. Alston. Much information has been taken from Mr G. S. Miller's recently published "Catalogue of the Mammals of Western Europe," the use of the MS. and proofs of which before publication was kindly permitted by the Trustees of the British Museum of Natural History.

ILLUSTRATIONS

FULL-PAGE.

FIGURES IN TEXT.

(*E. Museo Lundii*, iii., 60; and *Danmarks Pattedyr*, 90) has drawn attention to the fact that in the relatively small House Mice from Lagoa Santa, Brazil, $m\frac{3}{3}$ are in course of reduction, being sometimes wholly lacking, sometimes wanting from one or the other jaw, and when present always smaller than in European examples. In a skull from Cordoba these teeth are absent from both sides of the upper jaw, while they are greatly reduced in the mandible. There is thus ample evidence of the fact that *M. musculus* is capable of developing new forms adapted for leading a wild life amid foreign surroundings and among strange competitors.

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
SPECIMENS FROM REIGATE, SURREY, CAUGHT AND MEASURED BY L. E. ADAMS.					
SEXUALLY IMMATURE OF BOTH SEXES:—					
1. 19th Feb. 1912, average of 7; furred above, eyes and ears closed . . .	44	35	13	5·5	3·5
2. 19th Feb. 1912, average of 4; furred above, eyes and ears closed . . .	45	33	13·5	6	4
3. 19th Feb. 1912, male; furred above and slightly below, eyes and ears closed .	53	41	14	6	5
4. 19th Feb. 1912, female; fully furred, eyes and ears open	55	64	18	12	7
5. 28th Aug. 1913, male; full first pelage .	58	62	17	11	8
6. 17th Dec. 1912, male	59	59	16	11	7
7. 30th Dec. 1912, female	59	60	16	11	10
8. 29th April 1913, male; adult pelage above, almost adult below . . .	60	58	17	12	8·5[1]
9. 19th Feb. 1912, female; adult pelage above, almost adult below . . .	64	74	17	13	11[1]
10. 29th Aug. 1913, male; complete adult pelage	64	68	17	12	9
11. 2nd May 1913, male; nearly full pelage	65	62	17	12	8·5
12. 29th Aug. 1913, male; complete adult pelage	65	65	17	11	9
13. 8th Aug. 1913, male; first pelage below	67	65	16	12·5	10
14. 9th Aug. 1913, male; complete adult pelage	67	67	16	12	10
15. 11th Oct. 1911, female; complete adult pelage	68	64	19	13	8
16. 8th Aug. 1913, male; complete adult pelage	68	69	16·5	11·5	12
17. 31st Aug. 1913, female; not quite adult pelage below	69	64	17	12	9
18. 13th July 1913, female; complete adult pelage	69	72	16	12	11
19. Jan. 1912, male; complete adult pelage.	69	77	17	13	10
20. 15th Feb. 1913, female; complete adult pelage	70	67	15·5	11	13
21. 29th Aug. 1913, female; adult pelage, but imperforate	70	75	16	12	12
22. 1st May 1913, female; adult pelage, but imperforate	83	78	16	12	15

[1] Nos. 8 and 9 are respectively the minimum and maximum of a series of seven recorded in Adams's original table.

SPECIMENS FROM REIGATE, SURREY—(*continued*).

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.		Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
SEXUALLY MATURE MALES:—						SEXUALLY MATURE FEMALES:—					
1. 11th Oct. 1911	81	83	22	16	15	1. Oct. 1911	70	70	21	13	10
2. ,, ,, ,,	79	78	17	13	15	2. ,, ,, ,,	75	78	21	15	12[1]
3. ,, ,, ,,	83	76	17	13	16	3. ,, ,, ,,	83	77	17	13	17
4. 12th Jan. 1912	84	80	17	11	17	4. 11th Dec. ,,	83	83	17	13	18
5. ,, ,, ,,	79	80	18	12	15	5. ,, ,, ,,	73	75	16	12	12
6. ,, ,, ,,	75	75	17	12·5	13	6. ,, ,, ,,	74	74	17	13	14
7. ,, ,, ,,	74	73	17·5	11	15	7. Feb. 1912	90	84	18	13	30[2]
8. ,, ,, ,,	79	78	18	12	14	8. ,, ,, ,,	73	73	18	13	14
9. ,, ,, ,,	80	79	17	12	15	9. ,, ,, ,,	83	80	17	13	24[3]
10. ,, ,, ,,	81	77	17	13	14	10. ,, ,, ,,	75	82	18	11	15[4]
11. 20th ,, ,,	75	70	17	13	14	11. ,, ,, ,,	76	72	17	13	19[5]
12. 13th Feb. ,,	81	75	17	14	15	12. ,, ,, ,,	77	82	18	14	19[6]
13. 19th ,, ,,	72	76	18·5	12	16	13. ,, ,, ,,	80	83	17	18	21[7]
14. ,, ,, ,,	82	77	17	12	16	14. ,, ,, ,,	75	76	18	12	18[8]
15. ,, ,, ,,	83	81	19	14	21	15. ,, ,, ,,	71	73	18	11	16[9]
16. ,, ,, ,,	75	78	18	13	17	16. ,, ,, ,,	70	79	18	11	16
17. ,, ,, ,,	75	81	18	13	20	17. ,, ,, ,,	77	79	17	14	14[10]
18. 27th ,, ,,	76	78	18	12	13	18. ,, ,, ,,	78	72	18	12	13
19 28th May ,,	80	73	17	11·5	14	19. ,, ,, ,,	78	76	17	13	13
20. ,, ,, ,,	76	74	17	11	14	20. ,, ,, ,,	92	82	18	13	19
Average . .	79	77·6	17·7	12·5	15·6	Average . .	77·6	77·5	17·8	13·1	16·5

[1] From Bishop's Stortford. [2] With 7 large embryos. [3] Suckling; no embryos. [4] With 8 embryos. [5] With 5 embryos. [6] With 3 embryos. [7] With 6 embryos. [8] With 7 embryos. [9] With 7 embryos. [10] With 3 embryos.

FERAL SPECIMENS FROM NEAR INVERGORDON, EAST ROSS-SHIRE, CAUGHT AND MEASURED BY EWEN KENNEDY.

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
1. 12th May 1905	82	85	19	13	18·5
2. 15th ,, (male)	70	79	19	12	19·2
3. 15th May 1912	51	71	19	14	12·5
4. ,, ,, (male)	74	72	16	14	18·1

Remarks:—The largest specimen measured by Adams was a male taken at Clifton, Derbyshire, in January 1895; this had the head and body 95, and the tail 87 mm. long; its weight was 23 grammes. Adams found the average length of the head and body to be 78·6 in thirty-four males; 78·1 in twenty-eight females; and nearly 78·4 in the total of sixty-two of both sexes.

Skull:—In adults; condylo-basal length, 19·7 to 22; zygomatic breadth, 10·6 to 12·4; interorbital constriction, 3·5 to 4; breadth of brain-case, 9·8 to 10·4; median depth of brain-case, 6 to 7; length of nasal, 7·4 to 8·8; of diastema, 5 to 6·2; of mandible, 11·4 to 13; of maxillary tooth-row (alveolar), 3·4 to 3·6; of mandibular tooth-row, 3 to 3·2.

Distinguishing characters:—Specimens in the tawny outdoor pelage can readily be mistaken for young Field Mice, especially when both species are caught together. The short, broad foot, the characters of the palmar and plantar tubercles, the small eyes, the presence of ten mammæ in the female, and the peculiar odour, afford the surest means of identification; while the characters of the skull and teeth are, of course, absolutely diagnostic.

It is hardly necessary to describe the habits of such a familiar, elegant, and entertaining little thief as the House Mouse. Of very delicate build, its movements are rapid: running with great speed for short distances, it occasionally bounds and can make leaps from astonishing heights without sustaining injury. It is a good climber, and can swim well, although perhaps it does not take to water in normal circumstances. Though possibly possessing only indifferent sight, it is gifted with acute senses of smell and hearing, and is very quick to perceive and escape danger.

With the possible former exception of the Black Rat, no other mammal has been able to effect so strong, though uninvited, an alliance with man as the House Mouse. Few articles of human food come amiss to it, and few houses in Britain resist its invasion or refuse it shelter. It makes its home in all sorts of recesses, behind skirtings, beneath flooring and hearths, in cupboards, bookcases, church organs, pianofortes, and other heavy articles of furniture. It is mainly nocturnal in its habits, visiting hearths, tables, and larders in search of food; yet it not infrequently steals out of its hiding-place during quiet moments of the day. When present in small numbers mice do little harm, and their graceful movements by the fireside often compensate us for such damage as they cause. When the colony is a large one, however, they occasion much loss and annoyance; gnawing their way through woodwork and plaster, they sometimes cause considerable damage to property and fixtures; in the library they nibble away the margins of books, but, not finding ink palatable, they usually refrain from the text; articles of clothing and leather goods of all kinds may be attacked; holes are bitten in tablecloths and napkins where spotted by grease; and in the larder they attack every available food,

destroying far more than they eat by tainting it with their droppings and unsavoury odour. By climbing curtains and blinds they reach suspended bird-cages, stealing the seeds, and not infrequently injuring or killing the birds. In stores, warehouses, barns, granaries, and cornstacks they are, of course, an unmitigated nuisance, and the cause of great pecuniary loss. Immune from attack and multiplying in hosts, they drill the whole interior of a cornstack, forming a labyrinth of runs, and occasionally—with the assistance of Harvest and Field Mice—make incalculable havoc amongst the grain. At threshing, notwithstanding the fact that vast numbers succeed in escaping, hundreds may be killed in a single rick.[1]

Like rats, the House Mouse shows a propensity for following a definite track to and from its hole; advantage may be taken of this habit in trapping mice. It is often said to be suspicious of traps, especially those smelling of previous occupants; Adams (*MS.*) says this is difficult to prove or disprove, but he is inclined to disbelieve it, and thinks that when House Mice refuse to enter traps, it is either because they do not perceive the bait, or else because there is other food more to their taste near at hand. They will sometimes jump over traps placed in their path. Once when much troubled with mice, we set a trap between a fender and chimneypiece, through which aperture we had seen a mouse running on several occasions from the fireplace. We sat quietly watching the trap; in due course the mouse came out and leapt safely over the trap; we gently tapped the floor with a foot, and the mouse turned and jumped back again. A few minutes later the mouse and we repeated this perform-

[1] This species frequently plays a great part in the development of a mouse plague. Perhaps the most serious instance has been afforded recently by the great mouse plague in South Australia and Victoria, in which the House Mouse was the chief species involved. The plague developed in the bush as well as in the wheatland in 1916 and 1917, after two abnormally heavy harvests. The wheat had been sold to the British Government, and it lay stacked in bags ready for shipment. Ships were lacking; and the stacks remained unprotected from a possible attack by the rodents. As cold weather approached, the mice invaded the stacks and quickly produced ruin and disease. The damage done to wheat is estimated to be well over £1,000,000, and much damage was done also to other property. Myriads of mice were present; thus 70,000, weighing about one ton, were killed in an afternoon in one wheatyard alone (Hinton, *Rats and Mice as Enemies of Mankind*, Economic Series, No. 8, British Museum, 1918, p. 41).

ance. Finally the mouse made a third exit over the trap; we stamped the floor loudly, and (rather sorrowfully) saw the frightened little beast jump on to the trap in trying to return to its home. If alarmed in a room, a mouse will usually try to reach its hole by running round close to the wall, or along the top of the skirting, seldom taking a direct course across the floor.

Though usually extremely timid, the House Mouse sometimes, when not molested, will show a certain amount of impudent boldness. We know of one case where a mouse entered a paper bag containing biscuits, and began to nibble them, with much rustling, within a few inches of a man lying in bed reading.[1] We knew an actor who used to eat a lonely and frugal supper long after midnight. One night a mouse climbed on to the cloth at the other end of the table, and finding our friend both harmless and hospitable, it became a regular visitor. Nor is such audacity exhibited before man alone, for Mr Beavan mentions mice running between the legs of the Golden Eagles and scampering over the Tiger at the Zoo.

The eyes of the House Mice are described by Prof. C. V. Boys (*Nature*, 1st February 1912, 447) as being "autophanous"[2]—shining pale ruby or rather spinel—and

[1] Mr Cocks (*in lit.*) says:—"One night, soon after I had fallen asleep, I was awakened by a mouse sitting on my pillow, nibbling my hair (I use no lubricant). I stealthily put my arm up and made a grab, but not being able to see it, besides, perhaps, being hardly fully awake, I missed the mouse, which jumped off the bed and ran away. I soon fell asleep again, but before long was again awakened by the mouse eating my hair; the process as just described was repeated not only that once but two or three more times, at intervals of perhaps half an hour or rather longer. At last I made rather a better shot and touched the mouse, though again failing to secure it, and it finally disappeared. The mouse no doubt was ravenously hungry."

[2] The term "autophanous" was introduced by Col. J. Herschel (*Nature*, 18th Jan. 1912, 377) to describe eyes which (like those of cats and dogs) appear to emit light, by shining when seen in the dark. Such eyes are, of course, not autophanous at all (as Herschel points out); they merely reflect light which is seen when the eye of the observer is nearly in line with the illuminating source; and they act exactly as do the "reflex lights" used by cyclists. When the retina is backed by black pigment, as in normal men and monkeys, the eye is not autophanous, but forms the best possible means for obtaining sharp and clear vision. When the pigment is lacking, the retina rests directly upon a burnished surface—the tapetum; the eye is then autophanous; and while clearness of vision is impaired, the greatest possible power of detecting motion, in objects under observation, is conferred.

they do not mind being illuminated, if there is no conspicuous movement. This writer also found them not to mind loud noises or singing, provided "s," "k," "or other sudden sounds" were not used.

The little, shrill squeaks, uttered in rapid succession when pairing, fighting, or alarmed, constituting the normal voice of the House Mouse, are familiar to all. Mice are supposed by some to be fond of music, and the remarkable songs of "singing mice," resembling as they do occasionally the trills of canaries and other song-birds, have caused others, as Bordier, to claim that mice are sometimes capable of learning to imitate singing birds, and even of teaching this art to subsequent pupils, situated in less favourable circumstances. Brehm, a sceptic himself, mentions that a traveller records that the inhabitants of Central China keep mice instead of canaries in their cages, and that the songs of such "birds" fill Europeans with astonishment.

"Singing mice" have been heard by many in Britain, France, and Germany, and they have given rise to much literature and controversy. These mice make their appearance in houses, where previously the mice have possessed merely normal voices; in some cases only one individual sings, but in others a nest or the entire colony have the power of song. Sometimes the song is heard only towards dusk, or in the night; sometimes it is heard both by day and night; it may be continuous, or it may last for longer or shorter periods, alternating with more or less prolonged intervals of rest. In one case where the mouse sang both in the daytime and by night, a song lasted for ten minutes at the most during the day, but for fifteen minutes or more at night. The song itself is variously described, but appears to have little in common with the ordinary voice of a mouse. At its worst (in a male albino), it is a chirping, a medley of sounds, affording not the slightest resemblance to the clear notes of a canary or the deep trills of a thrush, but audible in the quiet of night at a distance of twenty paces (Schacht); or something between the sound of a wren and shrew, rather pleasing than otherwise (Slater). In other cases the listener has heard in it sweet thrilling notes, uttered very rapidly like the trills of a

very voluble canary, sometimes loud and piercing, and sometimes dying away into the softest of cadences. Mr Coward (*in lit.*) describes one which he heard in June 1912 as sounding like a weak-voiced canary; its notes were sung with great rapidity, almost in a trill, and its compass was thought to embrace half a dozen notes or more, of which the higher ones were decidedly sweet. Mr Sidebotham described one which he heard in an hotel at Mentone in 1877,[1] whose song was not unlike that of canaries in many of its trills, but had more variety, some of its lower notes being much more like those of the bullfinch. Moreover it had a sort of double song, an air consisting of loud and full, though low, notes, and a quite subdued accompaniment; so striking was this that some, when hearing the mouse for the first time, attributed the song to two singers. A young mouse of normal appearance kept by Prof. Liebe appears to have been the most accomplished vocalist hitherto described; its voice ranged through two octaves, the notes partly resembling the high tones of the lark, partly the long-drawn, flute-like tones of the nightingale, and partly the deep, liquid trilling of the canary, and it distinguished itself by its beautiful cadences. Although occasionally pleasing or even beautiful, the melody emitted by mice is said to lack any definite or strophic character. The mice have no sense of time, and Mr English says that the effect of a number of them singing in chorus, but out of time, is ludicrous.

A "singing mouse" may give vent to its song in all sorts of positions and when engaged in all sorts of actions, as when sitting, cleaning itself, climbing or descending, running or eating. In some cases the throat has been observed to vibrate during the song, and the snout has been held in the air, and extended like that of a dog when howling. Mr Romanes found the song to be evoked by two opposite conditions—when undisturbed, his mice were quiet during the day and began to sing at night, but when alarmed, by handling or otherwise, whether during the day or night, they were sure to sing vigorously; these two songs of contentment or fear respectively

[1] Mr Coward tells us that his father heard a singing mouse in a room of an hotel at Mentone about 1877; possibly this was the individual described by Mr Sidebotham.

differed somewhat in character. Others have noted more vigorous singing by the mice after changes in the weather, or when feeding or cleaning themselves, or when in the presence of a numerous human company.

Some observers are disposed to regard the song as a sexual call peculiar to some males; it so happens that, if we reject as unreliable Mr English's determination of the female sex of a large singing mouse which he saw running away, the few cases where the sex has been definitely recorded are all males; but really there is no evidence of such a restriction, and it is difficult to imagine that the occasionally large colonies of such mice do not include individuals of both sexes. Jackel (in Landois, 1882) thought that the song proceeded from a nest of young mice and their parents, clamorous with joy at reunion; some have attributed the song to contentment, pleasure, or fear; while others, though aware that possibly a diseased condition of the respiratory organs affords the most likely explanation, have been quite unable to detect any trace of disease or weakness in the quality of the sounds. Mr English thought that the performances of the colony studied by him were of a competitive kind, and he attributed the singing to hysteria. Liebe thought that the vocal powers of his mouse were due to the presence of a membrane in the windpipe which served to straiten the aperture. Dr Cohen examined a number of singing mice and found traces of inflammation in the windpipes of all; he attributed the song to the unhealthy and straitened condition of this organ, and regarded the quick mortality, found by himself and others among these mice, as further evidence of such unhealthiness. Landois also carefully examined a half-grown singing mouse. While Cohen heard the song only during inspiration, Landois's specimen emitted sounds continuously during both inspiration and expiration—the tone was louder and clearer during expiration, weaker during inspiration; there were four breaths, and therefore eight distinct and quite involuntary sounds per second; the sounds were shrill and light, but quite audible across a large room; when heard from a distance they were more sonorous, because the higher tones of expiration blended with each other and

were less interrupted; the rhythm was clearly due to respiration. Experiment and subsequent autopsy showed the song of this mouse to be due to an inflamed condition of the narial passages. Mr Slater, however, points out that his mouse was not short-lived, and that it begat a numerous progeny; while Herr Struck mentions that a singing mouse lived seven months, and another for more than nine months in captivity.

"Singing mice" of other species are known also; Landois mentions such among Field Mice,[1] Grass Mice, and Shrews. The Rev. S. F. Lockwood described a musical *Hesperomys* which had two chief songs, these being given in the description in musical notation; this case has been noticed by Darwin in *The Descent of Man.*

Reviewing all the facts relating to "singing mice" with which we are acquainted, we are inclined to think that in all cases the song is produced by a derangement of one or other of the respiratory organs. We are aware of no case in which a "singing mouse" has been proved to be healthy in this respect, and the few cases in which post-mortem examinations have been made have always revealed traces of inflammation. Sometimes the disorder is purely of an individual kind, but at others it appears to be contagious, and to affect young and old alike. In some cases the disease terminates in early death; while in others it seems to be a milder but chronic disorder, which apparently does not greatly diminish the vitality of the mouse or its power of reproducing its kind. That mice are capable of imitating song-birds, we disbelieve: many singing mice are recorded from houses where there have been no birds; and as Lataste points out, the shops of those dealers who store tame mice and song-birds together in large numbers, would have long ere this provided clear proof of such a remarkable faculty if such in fact existed.[2]

[1] See also p. 514 above.

[2] The following is the list of literature consulted in preparing the above account of "singing mice":—E. Newman, *Zoologist*, 1843, 288; J. Collins, *ibid.*, 1849, 2474; J. Farr, *ibid.*, 1857, 5591; H. Fry and E. Newman, *ibid.*, 1865, 9432; Bampfield in Wood, *Illustrated Nat. Hist.*, 1860, 558; Brehm, *Thierleben*, ii., 132; Hugo, *Proc. Verb. Soc. Zool. France*, ii., 1877, 87; Bordier, *La Nature*, 1876, 415, and 1877, 133; Brierre, *Fr. Soc. d'Acclim.*, 1877, and *Nature*, xvi., 1877, 558; H. H. Slater,

The Japanese have cultivated a breed of tame House Mice remarkable for their habit of running round and round in circles when in the open, whence they are called "dancing or waltzing mice." In 1894 William Blasius showed specimens to Barrett-Hamilton, and informed him that two or three will join to make one composite circle, and thus have a tendency to damage each other's tails; in apparent proof of which, Barrett-Hamilton noticed that the old mice had no tails, whereas a young one was well provided. These mice appeared to be tame white mice marked with black. Waltzing mice of various colours are known; in some the eyes are black, in others pink; the pink-eyed types breed true to that character. When exposed to light, such mice run round after their tails, spinning with great rapidity. Very often, if not invariably, the waltzing habit is correlated with a malformation of the internal ear, and "waltzers" are always of delicate constitution; but the physiological cause of the habit is not well understood at present. From the experiments made by Von Guaita and Darbishire it would appear that "waltzers" behave as complete recessives when crossed with normal non-waltzing types.[1]

It is of interest to note that "waltzing black rats" appeared in the course of Bonhote's breeding experiments, with the progeny of a cross between *E. r. alexandrinus* and *E. r. frugivorus* (*Proc. Zool. Soc.*, 1912, 6). These also proved to be very delicate.

The nest of the House Mouse is composed of soft materials such as straw, hay, woollen and cotton rags, or paper; these

Nature, xvii., 1877, 11; J. Sidebotham, *ibid.*, 29; G. J. Romanes, *ibid.*, 29; Landois, *Zool. Gart.*, 1871, 162, and *Jahresb. Westfal. Verein.*, xi., 1882-3, 17 and 21; Struck, *Arch. Ver. Mecklenburg*, xxxv., 117; Lataste, *Zooethique*, 1887, 287; Lockwood, *Amer. Nat.*, 1871, v., 761; Darwin, *Descent of Man*, 568, 865; A. H. Cocks, *Bucks;* Douglas English, *Some Smaller British Mammals*, 84; Coburn, *Journ. An. Behaviour*, ii., 1912, 364, and iii., 1913, 388; and T. Coward, *in lit.*, to Barrett-Hamilton, 2nd July 1912. Numerous other references will be found in some of the papers cited—notably in those of Landois and Struck.

[1] See Von Guaita, *Ber. Naturf. Ges. Freiburg.*, x., 1898, 317, and xi., 1900, 131; Darbishire, *Biometrika*, ii., 1902, 101, 165, 282, and iii., 1903, 1; Durham, *Rep. Evol. Comm. Roy. Soc.*, iv., 1908, 41; Bateson, *Mendel's Principles of Heredity*, 1909, 33 and 111; Alexander and Kreidi, *Monatschr. Ohrenheilk.*, Berlin, 35, 1901, 78; Yerkes, *The Dancing Mouse*, New York, 1907; Quix, *Amsterdam, Werk. Gen. Nat. Genees. Heelk.*, 1909, 83.

materials are usually first bitten into shreds. In comfortable surroundings and in the presence of abundant food, young are born in every month of the year, and one dam may have many successive litters in each year. Sometimes the young are dropped gregariously, several litters of different ages together, so that as many as fifty young mice have been found in a single nest.[1] The number of young per litter is variable, but seems to average between five and six; ten pregnant females examined by Cocks between the months of January and May of different years, contained nine, seven (twice), six (four times), five, four, and two fœtuses—giving an average of nearly six per litter. Barrett-Hamilton observed ten in a family born at Kilmanock in September 1910, and copulation took place immediately after parturition. Lataste (290) observed, in his tame specimens, a short period of rut, never longer than half a day, immediately following parturition; he found the period of gestation to vary between nineteen and twenty-one days normally,[2] or to last thirty-one days where lactation caused delay in development of the embryos. Others have observed much shorter gestation; thus Bonhote[3] gives it as about thirteen days, and Temple[4] recording that a Desert Mouse (*Gerbillus*) gave birth to one on 24th August and to four young on the following 5th September, also mentions that a similar period of twelve days was once observed in common fancy mice. Bonhote (*in lit.*) says that he does not doubt the correctness of Lataste's notes, but since he knows that a large variation in the period of gestation exists in *Meriones*, he expects that a similar variation may exist in the House Mouse.

The young are born blind, naked, and pink; but, according to Macgillivray, they grow so rapidly that in a fortnight they are able to shift for themselves. Lataste (304) found, subject of course to individual variation, young domesticated House

[1] *Field*, 8th February 1913, 283 ("Dabchick" and "Ed.").

[2] Quite a good though brief account of this species was given by Oken (*Allgem. Naturgesch.*, Bd. 7, Abt. 2, 716, 1838); he states the period of gestation as three weeks, the number of young as four to six, while ten might be nourished; and that the young can take care of themselves in fourteen days.

[3] J. L. Bonhote, *Proc. Zool. Soc.*, 1911, 5.

[4] W. R. Temple, *Field*, 13th September 1913, 620.

Mice at the sixth day commenced to be clothed, at the thirteenth day they were completely clothed, and had the external auditory meatus open; at the fourteenth to the fifteenth day the eyes opened; on the nineteenth day (but sometimes as early as the sixteenth) they were able to leave the mother, although they would suckle for a few days more if opportunity permitted; at this age their parents do not molest them, but soon after they will massacre the young. The male will copulate when $1\frac{1}{2}$ months old, and a female 116 days old bore young after copulation with a male of her own age. Lataste observed them to be very voiceful, crying at birth. Saint-Loup[1] finds the rate of growth to be most rapid immediately after birth; it then decreases continually during eighteen days; from the nineteenth to the twenty-second day it rises again, but without attaining a quarter of the initial rate; afterwards it fluctuates.

Despite their disagreeable odour, which impregnates their cages and everything they touch, many find tame House Mice attractive pets; there is a National Mouse Club, and "shows" are held at which prizes are awarded to the best representatives of the very numerous recognised classes or breeds. These mice have long been tamed, and certain of the coloured races are of respectable antiquity; thus Merrett (*Pinax*, 167, 1667) was acquainted with white, ashy and dark varieties, and it is worth noting that he does not speak of coloured rats. Brehm (*Thierleben*, ii., 134) states that tame mice are fond of spirits, but Lataste found that pure rum had no attraction for those kept by him. The latter writer describes his captives as being essentially, though not absolutely, nocturnal; with well-developed senses, and intelligent, though not so well endowed in these respects as the Brown Rat; they are excellent climbers, with feebly, but really, prehensile tails, which are especially useful to them in balancing exercises, in which they excel; they have a sense of property, and are peculiarly gentle, perhaps from long domestication, and readily handled; they are friendly to each other, unless treated foolishly or badly fed; a single cage, however, will only hold the parents and young, and the young must be removed when they become

[1] R. Saint-Loup, *Bull. Zool. de France*, 1893, 242.

rivals of their parents. Wild House Mice are said by some to be much less easily tamed than Field Mice, but others, as Lataste, state that they are easily tamed with care; no doubt much depends upon the mouse, the circumstances, and the experimentalist. Adams (*MS.*) used to breed "white mice," and he thought them "deficient in some way (sight, hearing, like white cats with blue eyes:") he noted that when they produced a litter of normal grey ones, these were invariably more active and wild, often escaping when being handled, even when quite young. Similar experiences were recorded by Darbishire.

With regard to longevity, Chalmers Mitchell (*Encycl. Brit.*, 11th ed., 16, 976*a*) says that the House Mouse may attain an age of five or six years; Oken (*op. cit.*, 716) says that "one can keep them for six years, from which it follows that they live still longer in freedom." We should not have expected such a small rodent to have attained so great an age, but we are aware of no other authoritative statements upon the subject.

2. THE ST KILDA HOUSE MOUSE.

MUS MURALIS, Barrett-Hamilton.

1899. MUS MURALIS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 81, pl. ix., fig. 2; type of female, No. 8.7.16.1 of British Museum collection, from St Kilda, Miller, *Catalogue*, 874.

1905. MUS MUSCULUS MURALIS, J. G. Millais, *Mammals of Great Britain*, ii., 198; Trouessart.

1908. MUS MUSCULUS, H. Winge, *Danmarks Pattedyr*, 88 (in part).

Distribution:—Restricted to Hirta, the only inhabited islet of the St Kilda[1] group, whence it is alone known. Here it is very abundant in the houses, but occurs also in the crofts, finding shelter in the walls and "cleits" (Eagle Clarke, *Ann. Scott. Nat. Hist.*, 1914, 127).

History:—Steele Elliott (*Proc. Birmingham Nat. Hist. and Phil. Soc.*, 1895, 135; and *Zoologist*, 1895, 281) first obtained specimens of this mouse in May 1894; he noticed "a slight difference in its coloration from those found with us," but did not describe it further. Barrett-Hamilton (*op. cit.*, and *Ann. Scott. Nat. Hist.*, 1899, 31), working with

[1] As noted on p. 640 above, it is possible, however, that a representative of this species occurs on North Uist, Hebrides.

one of Steele Elliott's specimens and others collected in 1898 by Henry Evans, published a full description and figure of the animal, and established a new species, his *M. muralis*, for its reception. He thought that this mouse was "of at least several hundred years' standing at St Kilda," and while realising that it was very closely allied to *M. musculus*, he thought it better to regard it, pending further research upon the status of the various described members of the group, as a full species rather than as a sub-species of *musculus*. In 1906 Barrett-Hamilton (*Ann. Scott. Nat. Hist.*, 2) described a further series of specimens collected by Waterston in June 1905. In the autumns (September and October) of 1910 and 1911 Eagle Clarke made another collection, and he described these specimens in 1914 (*Ann. Scott. Nat. Hist.*, 127).

The **status** of *M. muralis* has been discussed by various writers. Lydekker (*Field*, 30th April 1904) and Winge (1908) regard it as no more than a local race, while Millais and Trouessart treat it as a sub-species of *musculus*. Barrett-Hamilton (*Proc. Zool. Soc.*, 1899, 81) thought that since this mouse was perfectly isolated, and not known to intergrade with the parent form (*musculus*), it had "as much claim to be accorded full specific rank as any other island species." After examining all the European members of the genus, Miller came to the conclusion that *muralis* is sufficiently well differentiated to receive full specific rank. For reasons given above (p. 648), Miller's view has been adopted here, although not without hesitation.

If Miller's decision to regard the wild forms of southern and central Europe (*M. spicilegus*) and the island House Mice (*M. muralis* and *færoensis*) as distinct species be really well founded, it is possible that these species represent a more ancient stock of House Mice indigenous to western Europe. The distribution of these forms is in favour of such a theory; and the large size of the jaw from the Kirkdale Cave (see p. 636), assuming that specimen to be of Pleistocene age and really referable to this genus, figured by Owen, could be explained by referring it to a forerunner of *muralis*. Our knowledge of the matter, however, is still far from sufficient to raise any such view above the rank of a mere hypothesis.

Description:—In outward form *M. muralis* agrees closely with *musculus*, but differs in being rather larger, and in having the tail and feet more robust. The width of the hind foot, measured across the bases of the outer toes, is about 4 mm., instead of 3·5 mm., as in *musculus*.

In general **colour** the back is rather lighter than in ordinary specimens of *musculus*, the bases of the hairs are slaty, and while most of them have sepia-brown tips, a certain proportion are rufous-tipped, and give the animal a grizzled appearance. The under parts are bright

THE FIELD MOUSE.

buff or buffy white, this colour being clearly separated from that of the upper surface by a well-marked line of demarcation.

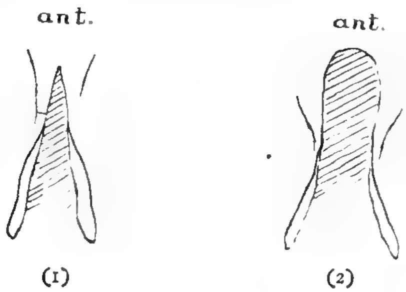


FIG. 95.—DIAGRAM OF PALATE OF *Mus muralis* (1), AND *Mus musculus* (2).

The **skull** is slightly larger than is usual in *musculus*, and the mesopterygoid fossa (Fig. 95) is greatly narrowed in front, the pterygoids converging anteriorly instead of being approximately parallel. This character, less marked in young skulls than in adults, appears to be quite constant in *muralis*, and it has not yet been observed among the large number of European skulls of *musculus* examined. The **teeth** do not differ from those of *musculus*.

DIMENSIONS IN MILLIMETRES OF *M. MURALIS* AND *FÆROENSIS*:—

	Head and body.	Tail (without terminal hairs).	Ear (greatest length).	Hind foot (without claws).
Mus muralis.				
1. 1898. Female (B.M. 8.7.16.1; type), collected by H. Evans	90	85	17	14
2. Average of 6 females (from spirit), on which original descriptions were based (Barrett-Hamilton, *Ann. Scott. Nat. Hist.*, 1906, 2). . .	85·1	81·5	16·5	12·9
June 1905. Collected by J. Waterston, and described by Barrett-Hamilton, *op. cit.*—				
3. Male	87	81	17	12·5
4. Female	93	89	18	14·5
5. Do.	96	92	18	13
6. Average of 9 adults, 3 male and 6 female, collected by Waterston .	84·6	81·4	17·4	13·16
Sept.-Oct. 1910 and 1911. Collected and described by W. Eagle Clarke, *Ann. Scott. Nat. Hist.*, 1914, 127[1]				
7. Male (largest)	104·5	74	16·7	13
8. Do.	103	95·6	18·5	14
9. Do. (smallest)	94	81	17	14
10. Average of 12 males	99·3	83·4	18·5	14
11. Female (largest).	111	90·5	20	16
12. Do.	105	87	19	14
13. Do. (smallest)	94	77·5	19	14
14. Average of 17 females	101·4	81·9	18·3	14·6
Mus færoensis.				
1. Male (Eagle Clarke, *Proc. Roy. Phys. Soc.*, Edinburgh, xv., 164) . . .	95·5	96·4	20·2	13·5
2. Female (type) (Eagle Clarke, *Proc. Roy. Phys. Soc.*, Edinburgh, xv., 164)	103	95	21	14
3. Male (Miller, *Catalogue*, 875) . .	85	97	20	13

[1] Specimens with head and body 90 mm. or less excluded as immature.

Skull:—Condylo-basal length, 21 to 22·2 (at least), zygomatic breadth, 11·2 to 12·6; interorbital constriction, 3·4 to 3·8; breadth of brain-case, 9·8 to 10·2; depth of brain-case at middle, 6·8 to 7·2; length of nasal, 8 to 8·8; of diastema, 5·6 to 6·2; of maxillary tooth-row (alveolar), 3·4 to 3·8; of mandible, 12·2 to 13·8; of mandibular tooth-row (alveolar); 3 to 3·2. None of the specimens hitherto measured has had the teeth more than moderately worn, skulls with much-worn teeth are probably larger.

Mus færoensis, Clarke, remains to be noticed. This was originally described (*Proc. Roy. Phys. Soc.*, Edinburgh, xv., 1904, 163) as a subspecies of *musculus*, the type being a female, in the Edinburgh Museum, collected by Annandale and Marshall, in August 1903, on Naalsö, Færoes. In his *Catalogue* (875), Miller treats this form as a full species.

Like *M. muralis*, this mouse is remarkable for its large size, its hind feet are very robust, their width measured across the bases of the outer toes being 5 mm.; the tail is stout, its diameter near the base being about 4 mm., instead of 3·6 as in *muralis*, or about 3 as in *musculus*. In **colour** it is more like *musculus* than *muralis*; its upper surface shows "a mixtuie of rufous and greyish-black (the former predominating), the fur being blackish at the base, broadly margined with reddish-brown. A number of thinly distributed black hairs are also present. Under-surface a mixture of buff and pale grey, intergrading on the flanks with the tints of the upper surface. The ventral fur is pale grey at the base, broadly edged with buff" (Eagle Clarke).

Apart from its larger size (condylo-basal length, 25 to 23·4 mm.), the **skull** (Naalsö specimens) differs from that of *musculus* only in having the rostrum relatively more robust, and the brain-case perhaps a little more depressed; the mesopterygoid fossa, in the three skulls examined, is as in *musculus*.

Three specimens, in the Copenhagen Museum, from Myggenæs, another island of the group, have been described by Winge (in Clarke, *op. cit.*, 164). These also are "very stout, with exceptionally large feet, 'wild-coloured' (*i.e.* without the sooty colour common in specimens taken in large towns);" and the mesopterygoid space is contracted anteriorly, exactly as in *M. muralis*.

SCIUROMORPHA

The *Castoridæ* and *Sciuridæ*, or Beavers and Squirrels, belong to the SCIUROMORPHA—one of the three great tribes in one or other of which most of the living *Simplicidentata* can be readily arranged. Besides the two families in question, the *Sciuromorpha* comprise the American families *Heteromyidæ* (Kangaroo Rats and Pocket Mice) and *Geomyidæ* (Gophers). Winge claims the *Sciuromorpha* as descendants of an ancient rodentian stock, the *Aplodontiidæ*, of which the only living and doubtless much modified remnant is the remarkable genus *Aplodontia*, comprising the Sewellels or Mountain Beavers of the Rocky Mountain region.

The leading **character** of the *Sciuromorpha* is to be found in the **skull**, in which the infraorbital canal is always small, serving only for the passage of the infraorbital nerve and accompanying blood-vessels, and transmitting no part of the masseter muscle. In this feature the sciuromorphine skull departs widely from that of other rodents (in which the canal is large, lodging or transmitting a larger or smaller portion of the *masseter medialis* muscle), and resembles the skull of the majority of non-rodentian mammals. Nevertheless, according to Winge, the *Sciuromorpha* are descended from ancestors possessing, like other rodents, spacious infraorbital canals. In these ancestors the *masseter medialis* muscle had its normal rodentian strength and development, and part of it had its origin within the infraorbital canal; on the other hand, the deep portion of the *masseter lateralis*, arising on each side from the outer and fore part of the zygomatic arch, was not unusually large or powerful, and had not yet extended its area of origin above the level of the infraorbital foramen. In the living genus *Aplodontia* the masseter muscles still retain essentially this arrangement.

By degrees the deep portion of the *masseter lateralis* muscle became the principal means of moving the lower jaw during gnawing, and it gradually extended its area of origin upwards far above the level of the infraorbital foramen, and forwards to a greater or less extent over the surface of the ascending branch of the premaxilla. This muscle thus usurped much of the function of the *masseter medialis;* the latter therefore declined in importance and was gradually driven away from the infraorbital canal; the canal consequently was straitened, and resumed its normal mammalian status as a mere conduit for the facial nerve and vessels. Some trace of the former widened condition of the infraorbital canal can still be discerned in many living *Sciuromorpha*. Thus a little groove leading up towards the orbit from the edge of the infraorbital foramen seems to represent the closed part of the fissure—the more so since from the floor of the groove two muscles take origin, viz. the *dilator narini* and a muscle of the upper lip, which in *Muridæ* arise from the edges of the upper and outer walls of the wide canal.

CASTORIDÆ.

BEAVERS.

These are medium-sized or large rodents, formerly enjoying a wide distribution in Europe, Asia, and North America. They are known to date from the middle Oligocene of Europe and North America and from the Pliocene in Asia, but they are evidently of still more ancient origin. Represented in the Tertiary by seven or eight genera at least, the group has waned, having as its present sole survivor the genus *Castor*, or Beavers, now hastening towards extinction.

In relation to the *Sciuridæ*, the *Castoridæ* play a part resembling that of the *Microtinæ* towards the *Murinæ*. They have followed either a strictly terrestrial or an aquatic mode of living, as opposed to the freer, typically arboreal course pursued by the *Sciuridæ*. They are more primitive than the latter, in retaining a well-developed thumb, armed with a large claw; in lacking a bony roof to the orbit; and in having the

cavity of the auditory bullæ undivided by osseous septa. They also do not show the marked increase in the relative size of the brain characteristic of so many *Sciuridæ*.

On the other hand they have, in many respects, attained a far higher degree of specialisation than that manifested by *Sciuridæ*. The incisor teeth are enormously developed, and the peculiar rodent function of gnawing reaches in this family its highest expression. In adapting themselves to a hard, coarse vegetable diet, their cheek-teeth have become markedly hypsodont, and display, when the tubercular caps are removed by wear, a pattern of deeply re-entrant, transverse enamel folds. Only one premolar is present in the upper jaw on each side, the dental formula being consequently $i\frac{1}{1},\ p\frac{1}{1},\ m\frac{3}{3}=20$; and the cheek-teeth are arranged in anteriorly convergent rows. The temporal, masseter, and pterygoid muscles are all powerfully developed, their strength being betrayed in the skull by heavily-built zygomatic arches, a moderately salient sagittal crest and deep pterygoid fossæ, the latter becoming, as usual, deeper and more extensive in proportion as the angular processes of the mandible diminish in size. Except in the very highly specialised extinct genus *Castoroides*, from the Pleistocene of North America, the jugal articulates with the lachrymal, and the fibula remains distinct from, though often closely connected with, the tibia, both being features shared with the *Sciuridæ*.

The British members of the family belong to two genera—*Castor*, now locally extinct, though surviving as a mere remnant in parts of Europe and Asia, as well as in North America; and *Trogontherium*, now wholly extinct, and known only from the Pliocene and Pleistocene of Europe and Asia.

Genus CASTOR.

1758. Castor, Carolus Linnæus, *Syst. Nat.*, 10th ed., i., 58; type *C. fiber*, selected by tautonymy.

1806. Fiber, Dumeril, *Zoologie Analytique*, 18; a substitute for *Castor; nec Fiber* (Cuvier, 1800), which is a synonym of *Ondatra*, Link.

This genus has a circumpolar distribution, and comprises the Beavers of the Old and New Worlds. It evinces in a high

degree of perfection the family specialisations for gnawing, for subsistence upon coarse vegetable foods, and for burrowing. Above all it is peculiarly modified for an aquatic existence.

Castor is first known from the Pliocene of **Europe** and from the Pleistocene of **Asia**; in **North America** it apparently dates from the Pleistocene. All the living species are very closely related. The Old World Beavers are at present referred to a single species, *C. fiber*, because, owing largely to the lack of material, all attempts to work out the geographical variation of this widely distributed animal have failed. In North America *C. canadensis* is the chief and most widely spread species; of this, six geographical races or subspecies are now recognized, while one from California (*C. subauratus*, Taylor) and another from Newfoundland (*C. cæcator*, Bangs) have been described as distinct species.[1]

THE BEAVER.

CASTOR FIBER, Linnæus.

1758. CASTOR FIBER, C. Linnæus, *Syst. Nat.*, 10th ed., i., 58; described from Sweden. Of most subsequent authors.

1792. CASTOR FIBER ALBUS and SOLITARIUS, Kerr, *Animal Kingdom*, 222 and 224.

1801. CASTOR FIBER VARIEGATUS and FULVUS, Bechstein, *Gemein. Naturgesch. Deutschlands*, ed. 2, i., 913.

1803. CASTOR GALLIÆ, Geoffroy, *Cat. Mamm. du Mus. Nat. d'Hist. Nat., Paris*, 168; described from the Rhone, France.

1822. CASTOR NIGER, VARIUS and FLAVUS, Desmarest, *Mammalogie*, part ii., 278.

1829. CASTOR FIBER GALLICUS, Fischer, *Synops. Mamm.*, 287; a substitute for *galliæ*.

1833. CASTOR PROPRIUS, Billberg, *Linn. Samf.*, 34 in footnote; a substitute for *fiber*.

1907. CASTOR ALBICUS, Matschie, *Sitz.-Ber. Gesellsch. nat. Freunde, Berlin*, 216; described from the Elbe, Germany.

1907. CASTOR VISTULINUS, Matschie, *Sitz.-Ber. Gesellsch. nat. Freunde, Berlin*, 219; described from Western Poland.

Le castor and *le bièfvre* or *bièvre* of the French: *der Biber* of the Germans.

As will be seen from the above **synonymy** numerous names, founded either upon mere individual variations of colour, or upon vain attempts to define local races without sufficient material, have been applied to the European Beaver.

[1] Other subspecies have been described recently by W. P. Taylor in *The Status of the Beavers of Western North America*, Univ. California Publications, Zool., vol. xii., 413-495, March 20, 1916.

Terminology:—The English name of this animal has always been the "Beaver," the spelling of the word showing, as usual, considerable variation at different periods. The *New English Dictionary* mentions "*beofor*," "*befor*," "*byfor*," "*befer*," "*beuer*," "*bever*," "*bevere*," "*bevyr*," "*beauer*," and "*beavor*" as forerunners of the current form. Of these "*beofor*" and "*befor*" are the earliest, and appear in Ælfric's *Vocabulary* (*c.* 1000 A.D.) as the translation of the Latin *fiber*.

Local names:—(Non-Celtic)—"Spattletail" may have been an ancient local name for the Beaver; it is given as the translation of *Llostlydan y befyr*, "the Spattletail or Beaver," mentioned in the Anomalous Laws of Wales (*Laws and Instit. of Wales*, II., bk. xiv., 592; and Stubbs, *Lanc. Nat.*, 1910, 129). But in view of the fact that this name is apparently quite unknown to the makers of dictionaries, it seems more probable that the word was coined comparatively recently to serve as an apt translation of the Celtic *llostlydan* discussed below.

(Celtic):—Welsh—*Llostlydan* "the broad-tail": *llostlydan* or *Castor* occurs in the *Leges Wallicæ* or Laws of Howel Dda (book iii., ss. 11, 12), dating from the tenth century; *afangc* or *avanc* (discussed below under History).

Cornish:—*befer.*

Scotch Gaelic:—*Leas-leathan* (Highland Society's *Dict.*), *dobhran leas-leathan* (Shaw, *Gael. Dict.*, 1780), *leas-leathain* (Robertson).

The Welsh and Scottish Gaelic names cited above are descriptive, and there can be little or no doubt that they were applied to the Beaver. *Llost* or *leas*, with the Old Irish *loss*, signifies "tail," and *llydan* or *leathan* = "broad," hence *llostlydan* means "broad-tail." *Dobhran-chu* signifies "water-dog," or Otter, and therefore the combination *dobhran leas-leathan* = the "broad-tailed Otter," or Beaver.

The similarity of the Welsh and Scotch names is of course striking, but a good deal of doubt exists as to the status of *leas-leathan* in the Highland tongue. The Gaels could have had no personal knowledge of the Beaver in Ireland, and it is suggested by Robertson that on their arrival in Scotland they "borrowed a name from the native Pictish inhabitants." For a full discussion of this matter the reader may be referred to C. H. Alston's *Wild Life in the West Highlands*, 34. From what is stated below with regard to the etymology of the word "beaver," it is probable that the original and general Celtic name for the animal was not a descriptive term, like *llostlydan*, but a variant of the Old Aryan *bebhrus*; and thus one can account for the use of *befyr* in the Anomalous Laws of Wales, and for the presence of *befer* in Cornish without supposing that these words crept into Celtic vocabularies by contact with Anglo-Saxons. "Beaver" was probably common to the languages of both races long before they met on British soil.

History and past distribution:—The range of the Beaver in the

Old World formerly covered the whole of the forested region of Eurasia, from Lapland and Northern Russia southwards to Spain, Italy, and the Euphrates, and from Great Britain eastwards at least as far as the Lena. The Asiatic limits of its distribution are, however, still imperfectly known.

The remarkable habits and powers of the Beaver, its appearance, its beautiful fur, and its possession of castoreum—that secretion which through long ages was regarded by physicians as a panacea—could not fail to attract human attention from the very earliest times. Accordingly we find the animal described or noticed in many of the most ancient writings which have survived to our day, while etymological research indicates that the name "beaver" itself dates from a time far beyond the reach of any documentary evidence in our possession. In this place only a few of the more salient facts can be mentioned, but reference may be made to the great essay on the Beaver by Brandt,[1] who dealt exhaustively with the classical references and commentaries, and for the first time collected the many scattered fruits of previous research.

The word "beaver" is in one form or another common to all the Indo-Germanic languages, and it is traceable, with its equivalents the Sanskrit *babhru*, the old Persian *baŏvara* or *baŏara*, and the nearly allied Arabic *viverra*, to the Old Aryan *bebhrus*: the latter, according to the *New English Dictionary*, is a reduplicated derivative of *bhru* = brown, with sense of "brown" or "red-brown" or "brown water animal." It does not follow, therefore, that in every instance, when using a derivative of *bebhrus*, early writers were speaking of the Beaver. Any brown fur-bearing animal would be a "beaver" to the earliest Aryans. Gradually the use of the word was limited solely to such brown fur-bearing animals as were of aquatic habits, and during this period it signified not merely the Beaver, but the Otter, Ichneumon, and Water Rat as well. This comparatively restricted meaning was acquired certainly by the time the sacred writings of the old Persian and Indian peoples were written, for in them "beavers" are clearly indicated as water-dwellers and their killing is expressly forbidden. In fact, as regards certain of the Persian documents, both Spiegel and Brandt were inclined to think that the context showed that *baŏvara* really indicated the Beaver and no other animal, and that, therefore, the word had acquired, between 300 and 400 B.C., its modern fully restricted significance.

The ancient Greek writers called the Beaver χάστωρ or *castor*, and its peculiar secretion χαστόριον. The words *castor* and *castoreum* appear to be connected with and perhaps are derived from the Indian *kasturi* or *kastora*, which signify the musk-glands and secretion of the Musk Deer, *Moschus*. These glands have a somewhat similar appear-

[1] J. F. Brandt, *Mem. Sc. Nat. Imp. Acad.*, *St Petersburg*, vii., 1855, 78 and 339.

ance and position in the Beaver, and their secretion has a similarly pungent odour. Therefore the name may have easily been transferred from one animal to the other in a region where one of the two species was absent. Be this as it may, there is no room for doubting that the Greeks were referring to the Beaver; and although some of them, as Aristotle, were perhaps describing it from hearsay, others, as Herodotus, Dioscorides, and Strabo had a personal knowledge of the animal. Dioscorides pointed out that the castor-sacks were quite distinct from the testes, and that the widespread belief that the Beaver, aware of the object of the chase, castrated himself before the hunter in order to obtain deliverance, was nothing but a fable. Strabo described the Beaver as inhabiting the rivers of Spain, and mentions that the Spanish castoreum had less strength than that of the Beavers of Asia Minor. This latter statement may have been well founded, since it is known that the nature of the food has no small influence upon the quality of the secretion.

The name of the Beaver among the Romans was properly *fiber*, while *Castor* was at a later date borrowed from the Greeks; thus Pliny speaks of "*fibri, quos castores vocant*"; *castor* had nothing to do with the Latin *castrare*. Varro, Festus, and more recently Harting have sought the origin of *fiber* in *fibrum*, the bank of a stream, but there seems little reason to doubt that *fiber* is a derivative of *beblirus*, which probably came into the language by the Celtic route; the mode in which the initial *b* was transformed into *f* may be indicated by mentioning the Provençal *vibré*. Varro speaks of Beavers in the rivers of Latium, and a line in a fragmentary work of Plautus, "*Sic me subes cotidio quasi fiber salicem*," suggests that at about 200 B.C. the people of Umbria, Central Italy, had a personal acquaintance with the habits of this animal.

We are indebted to Lord Kilbracken (*per* Cocks) for referring us to Dante's *Inferno* (c. xvii., lines 19 to 25):—

> "Come tal volta stanno a riva i burchi,
> che parte sono in acqua e parte in terra;
> e come là tra li Tedeschi lurchi
> lo bevero s'assetta a far sua guerra:
> così la fiera pessima si stava
> su l'orlo che, di pietra, il sabbion serra."

"As at times the wherries lie on shore, that are part in water and part on land; and as there amongst the guzzling Germans the beaver adjusts himself to wage his war: so lay that worst of savage beasts upon the brim which closes the great sand with stone."

Dante, writing about 1310, thus uses the Beaver as an illustration familiar to his Italian readers; that he indicates a German instead of an Italian colony of these animals may be due to the fact that he could

not very well employ the adjective *lurchi*, demanded by the rhyme, in connection with his own countrymen.

Beavers lived in the delta of the Po as late as the sixteenth century; a specimen was dissected in 1541 by Amatus Lusitanas at Ferrara, and *Bebriacum* is an ancient place-name (between Cremona and Verona) recalling their former occurrence.

Beavers do not appear to have ever reached **Ireland**, although in Great Britain the genus dates from the Pliocene, and *C. fiber* itself perhaps from the Pleistocene. This absence from Ireland, among other facts, led Dr Scharff to believe that Ireland was separated from Britain in early or pre-Pleistocene times. That seems a too remote period for the rupture; but it is possible that the area of the present Irish Sea was then so depressed, marshy, and devoid of woodland as to fail to tempt the Beaver to proceed westwards of Great Britain.

In **England**, jaws and teeth of species not certainly distinguishable, with such materials, from *C. fiber* have been found, in scanty numbers, in the Upper Freshwater Bed (Cromerian) of West Runton, and in several of the Pleistocene river deposits—as in those of the Thames at Ilford, Grays and Clacton in Essex. Numerous skulls and several more or less complete skeletons of *C. fiber* have been recovered from the peaty deposits, dating variously from the Neolithic, Bronze and Romano-British periods. The earliest discovery of the kind appears to have been made by Dr John Collet in 1757: he records the finding of "heads of Beavers," with the bones of other prehistoric animals, in a peat pit at Newbury, Berkshire (*Phil. Trans.*, 1757, 100). John Hunter received later part of a skull and a lower jaw from a mosspit in Berkshire: these specimens quite likely came from Newbury, whence further remains were described by Owen in 1846 (*Cat. Foss. Roy. Coll. Surg.*, 1845, 35 and 244). In 1818 Okes recorded two lower jaws from the dried bed of an old channel—"the West Water"—connecting the Nene with the Ouse near Chatteris; this ancient water-way had been choked up for more than two centuries. Since those early days many discoveries of the kind have been made in England — in Somerset, Devon, Dorset, Hampshire, Wiltshire, Berkshire, the fens of Cambridge, Suffolk, Norfolk, and Lincolnshire, in Yorkshire, and in the valleys of the Thames and its tributaries in Middlesex, Essex, and Kent. As examples clearly dating from Romano-British times may be cited the finding of Beaver remains at Glastonbury and the discovery, by Cocks, of a nearly complete mandibular ramus in the Romano-British pile-village at Hedsor, Bucks. One of the most recent "finds" was made when enlarging the Royal Albert Docks at Canning Town in 1911; a nearly complete skeleton (now in the British Museum) was there found buried in the Alluvium, beneath a prostrate tree-trunk.

The Beaver was undoubtedly a very common British mammal in the later prehistoric periods, and to its activities we may owe some very striking features of the present English landscape. Thus in East Anglia, as Dr Henry Woodward (*Trans. Essex F. C.*, 1883, iii., 8) first pointed out, the inception of the fens may have been due to the destruction of the primitive woodland by the Beaver, and the obstruction of the natural drainage formed by prostrate tree-trunks as well as by regular beaver-dams. Stubbs (*op. cit.*) similarly ascribes the destruction of the Pennine woodland and the formation of the peat-mosses of Lancashire, etc., to the work of Beavers. Similar changes are being or have been recently wrought by the same agency on a large scale in North America (Geikie, *Textbook of Geol.*, 1893, 474).

In **Scotland** also the remains of Beavers have been discovered, on several occasions, in the marly beds commonly found at the bases of the peat-mosses. The earliest find recorded is apparently that made in the deposits of the Loch of Marlee, Kinloch, Perthshire, in 1788; here a Beaver skeleton was found in a marl-pit, beneath 5 or 6 feet of peat; the skull and haunch bones were presented to the Society of Antiquaries of Scotland by Dr Farquharson (*Minute*, 16th December 1788; Neill, *Edinb. Phil. Journ.*, 1819, l., 182). Neill (*op. cit.*, 184), to whom we owe much of our knowledge of the history of the Beaver in this island, describes a skeleton found in 1818 in the course of draining Middlestot's Bog, in the parish of Edrom, Berwickshire.

As the country became settled the Beaver grew scarce and eventually disappeared. Apart from human persecution it is perhaps doubtful whether a small island like Britain could have long continued to support a large population of Beavers. There is no doubt that the animal lingered on in the historic period, and it probably did not become extinct here before the thirteenth century. In the *Leges Wallicæ* (book iii., ss. 11, 12), dating from the first half of the tenth century, skins of Martens, Otters, and Beavers (*Llostlydan*) are mentioned; and while 24 and 12 pence respectively are stated to be the values of the skins of the first two species, that of the Beaver is valued at no less a sum than 120 pence. The fur is said to have been used for the trimmings of the royal robes, and the high price set upon it shows that even at that remote date the Beaver had become extremely rare.

Gerald de Barri, better known as Giraldus Cambrensis, lived in Ireland between 1185 and 1188, and in his *Topographia Hibernica* (*Distinc.*, i., c. 21) he notes the absence of the Beaver from that country. In 1188 he travelled through Wales with Baldwin, who was then preaching the Third Crusade. In his *Itinerarium Kambriæ* (book ii., c. 3) Giraldus, as translated by Sir R. Colt Hoare, states that "the noble river Teivi," in Cardiganshire, has a productive salmon "fishery

near Cilgerran, which is situated on the summit of a rock, at a place called Canarch Mawr" (now Cenarth). He adds:—"The Teivi has another singular particularity, being the only river in Wales, or even in England, which has beavers; in Scotland they are said to be found in one river, but are very scarce. I think it not a useless labour, to insert a few remarks respecting the nature of these animals; the manner in which they bring their materials from the woods to the water, and with what skill they connect them in the construction of their dwellings in the midst of rivers; their means of defence on the eastern and western sides against hunters, and also concerning their fish-like tails." After reciting the early fable as to the means by which Beavers transport timber he proceeds:—

"In some deep, still corner of the river, the beavers use such skill in the construction of their habitations, that not a drop of water can penetrate, or the force of storms shake them; nor do they fear any violence but that of mankind, nor even that, unless well armed. They entwine the branches of willows with other wood, and different kinds of leaves, to the usual height of the water, and having made within-side a communication from floor to floor, they elevate a kind of stage, or scaffold, from which they may observe and watch the rising of the waters. In the course of time, their habitations bear the appearance of a grove of willow trees, rude and natural without, but artfully constructed within. . . . It is worthy of remark, that the beaver has but four teeth, two above, and two below, which being broad and sharp, cut like a carpenter's axe, and as such he uses them. They make excavations and dry hiding-places in the banks near their dwellings, and when they hear the stroke of the hunter, who with sharp poles endeavours to penetrate them, they fly as soon as possible to the defence of their castle, having first blown out the water from the entrance of the hole, and rendered it foul and muddy by scraping the earth, in order thus artfully to elude the stratagems of the well-armed hunter, who is watching them from the opposite banks of the river." Giraldus, like other ancient writers, then relates how the Beavers ransom themselves by self-castration, and concludes his narrative with the following:—"The beavers have broad, short tails, thick like the palm of a hand, which they use as a rudder in swimming; and although the rest of their body is hairy, this part, like that of seals, is without hair and smooth; upon which account, in Germany and the Arctic regions, where beavers abound, great and religious persons, in times of fasting, eat the tails of this fish-like animal, as having both the taste and colour of fish."

In his *Description of England*, written about 1577 and prefixed to Holinshed's *Chronicles*, Harrison says:—"For to saie the truth we have not manie Bevers but onelie in the Teifie in Wales."

This statement may, of course, be only a plume borrowed from Giraldus.

The three references just dealt with constitute the whole of the reliable documentary evidence relating to the Beaver in England and Wales at present known. It is true that Price and Llwyd, in a *History of Wales* written in the reign of Henry VIII., have identified the *Castor* of Giraldus with a water beast called by the Welsh *afangc* or *avanc*, and in this they have been followed by the compilers of Welsh Dictionaries; our authors added that only the name of the beast lingered in Wales in their day, and "what it is very few can tell." Camden, Ray, and Pennant call attention to a pool in the Conway, not far from Bettws y Coed, at the junction of Denbigh and Carnarvon, called *Llyn yr Afangc*, or the Beaver Pool; to another pool bearing the same name in Montgomeryshire (between Moat Lane and Llanidloes); and also to a little valley called *Nant Ffrancon*, in Carnarvonshire, the name being supposed by the natives to be a corruption of *Nant yr Afancwn*, or the Beaver Hollow. Pennant adds:—"I have seen two of their supposed haunts: one in the stream that runs thro' Nant Frankon, the other in the river Conway a few miles above Llanrwst; and both places, in all probability, had formerly been crossed by Beaver dams." Hoare points out that if the *Afangc* be identical with Gerald de Barri's *Castor*, then the latter cannot have been confined to the Teivi; and he quotes Owen-Pughe, who, in his Welsh Dictionary (published 1801), says that the *Afangc* "has been seen in this vale (*i.e.*, *Nant Ffrancon*) within the memory of man." Hoare concludes that the *Afangc* is nothing more than an obsolete or perhaps a local name for the Otter, and this view has received Harting's approval (*Extinct Brit. An.*, 37). The animal described by Giraldus is undoubtedly the Beaver. That old writer was not only an acute observer, he was a Welshman as well. It is therefore very difficult to think him mistaken when he describes the Beaver as being restricted to the Teivi; the more so since he obviously took much interest in that point. But at a still earlier period, in Romano-British times and probably for some centuries later, the Beaver had certainly a wide distribution in both England and Wales. Therefore, notwithstanding the fact that the modern animal mentioned by Owen-Pughe was in all probability nothing but an Otter, there is no reason why *Afangc* should not have been the name of the Beaver in North Wales long before the time of Giraldus; and this view would be in complete harmony with the statement of Price and Llwyd quoted above.[1]

[1] Canon Fisher tells us that the use of *Afanc* = Beaver in Welsh is comparatively modern; it was used for an aquatic monster, like the Irish *piast*. Owen-Pughe dropped the reference to Nant Ffrancon in the second edition of his Dictionary (1832).

The Beaver has apparently given rise to a fair number of English place-names. Thus we have the name (and arms) of the town of Beverley, Yorkshire; Bevercoates, Notts; Beversbrook, Wilts; Beverstone, Gloucestershire; the Barbourne or Beaverbourne, associated with Beaver Island and Beverege, Worcestershire; and Beverley Brook, Battersea (mentioned as *Beferith* in an original charter, dated A.D. 693).

With regard to Scotland the documentary evidence is less satisfactory than that respecting Wales. The earliest record appears to be that described by E. R. Alston as follows:—"In a capitular of export duties of David I., 1124-1153, skins of *Beveris* are included (*Acts Parl. Scot.*, i., 303); but they are not mentioned in a similar Act of 1424. The late Prof. Cosmo Innes, however, pointed out to me that too much trust must not be given to these documents, as the lists of commodities appear in some cases to have been adopted from similar English or foreign enactments."

Notwithstanding the non-appearance of the Beaver in the Act of 1424, Boethius, in 1526, included it in his list of the animals which abounded around Loch Ness, and whose furs were in request for exportation; and Bellenden, who published a vernacular translation of Boethius in 1536, accepted the "Bevers," although he omitted the stags, roe-deer, and otters of the original list. Little can be based upon this, however, for, as Neill pointed out (*op. cit.*, 179), Bellenden's translation shows carelessness and looseness; moreover, Boethius himself may have quoted the Beaver merely from hearsay. In 1684 Sibbald contented himself with saying:—"Boethius dicit fibrum seu castorem in Scotiâ reperiri; an nunc reperiatur, nescio."

Some further evidence that the Beaver survived in Scotland until the historic period may perhaps be found in the *Losleathan* tradition. Neill (*op. cit.*, 181) says that Walker used to mention in his lectures that "the Scots Highlanders still retain, by tradition, a peculiar Gaelic name for the animal." This was confirmed by Dr Stuart of Luss, a well-known Celtic scholar, who in a letter to Neill wrote:—"The name is *Losleathan*, derived from *los*, the tail, point, or end of a thing, and *leathan*, broad; or *dobhran losleathan*, the broad-tailed otter." Stuart added that he "recollected to have heard" of a tradition among the Highlanders "that the beaver, or broad-tailed otter, once abounded in Lochaber." As Neill says, "It is rather a puzzling circumstance, that, in the poems of Ossian, no mention should occur of the *losleathan*, an animal whose manners must have struck with admiration a rude people, and whose fur must have been invaluable in the eyes of the Fingalian heroes and their ladies." C. H. Alston, in his review of recent inquiries respecting this tradition, says:—"To the most intelligent and well-informed Gaelic-speaking Highlanders of to-day the words *Dobhar-chu* or *Dobhran-losleathan* appear to have but the

vaguest or no significance; at most one will be told 'a kind of otter.'" He adds:—"One cannot but infer that the existence of the beaver in Scotland must be relegated to a very remote period indeed, and that they were extinct long before the time when they disappeared from Wales. Possibly, too, they may have been always sparsely distributed, and confined to a few favoured localities." It is sufficient to say here that we are in full agreement with these conclusions.

The history of the Beaver in western continental Europe resembles that which we have traced in Britain. The animal was widespread, although apparently scarce, during the Pleistocene. It became quite common in the Neolithic period, when it appears to have played no unimportant part in bringing about the swampy conditions favouring the growth of peat. Its remains have been found, in abundance and at a large number of localities, beneath the peat-mosses of Skandinavia, Denmark, Germany, Holland, Belgium, and France. In Denmark it became extinct before the historic period.[1] Elsewhere, in face of advancing civilisation, and partly because of direct persecution, colony after colony has vanished, and the species has been brought close to total extinction. In the eighteenth and the beginning of the nineteenth centuries, although its numbers had greatly diminished, colonies were to be found in favourable localities scattered over a very large portion of its former range. At the present time, so far as Western Europe is concerned, the Beaver is found only in South-western Norway, in the Elbe, and in the delta of the Rhone. In each of these localities it now enjoys theoretically complete protection. Of these living colonies, the Norwegian are the most important; Collett says several hundred individuals must be living there, and their numbers are not at present decreasing.[2]

The former wide distribution of the Beaver in continental Europe is witnessed, in all countries save Iberia, by a very large number of place-names; lists of these will be found in Linstow's paper cited above.

Distribution in time:—The geological history of *C. fiber* has been discussed under History and Distribution. The earliest known

[1] Winge, *Vidensk. Medd. Naturh. Foren. Köbenhavn*, 1904, 224 and 303; and Collett, *Norges Pattedyr*, 188.

[2] For a valuable summary of facts relating to former and present distribution of Beavers and for Bibliography, see O. von Linstow, *Die Verbreitung des Bibers im Quartär. Abh. u. Ber. Mus. Nat. Heimatk. Magdeburg*, 1908, i., 213-387. For accounts of living colonies the following may be referred to:—A. H. Cocks, *Zoologist*, 1880, 233, 497; 1881, 54; 1882, 15; 1885, 479; Collett, *Nyt Mag. f. Naturvidensk.*, 1883, p. 11; 1898, 35; *Bergens Mus. Aarbog*, 1897, and *Norges Pattedyr*, 1911, 186; Harting, *Zoologist*, 1886, 265; 1888, 182, 260; Mitford, *ibid.*, 1896, 184; Mingaud, *ibid.*, 1896, 184; *Bull. Soc. Ét. Sc. Nat. Nimes*, 1906 to 1910. The colony in the delta of the Rhone must be one of the most interesting in the world, for since there is little or no timber at hand, the Beavers must lead what is practically the life of a huge Water Rat. Nine captured when the water fell to an unusually low level in

British species is *C. veterior*, Lankester, from the Red Crag of Suffolk (Pliocene). In this, certain of the enamel folds of the molars are reduced to "islets" sooner than in *C. fiber*, and the premolars appear to have been relatively larger. In these characters this species makes some approach towards *Trogontherium*.[1] Jaws of another species, *C. plicidens*, Forsyth Major, first described from the Pliocene of the Val d'Arno, have been found in the Norfolk Forest Bed. This species is characterised by its broader incisors, slightly larger cheek-teeth, and especially by "the complex and elegant plication" of the enamel of the molars.[2]

Description:—The Beaver is a large heavily-built animal (head and body, 820; tail, 380; hind foot, 170), with a rounded water-rat-like head, short, heavy limbs, and remarkably modified tail. The upper lip is not cleft, and the nostrils are separated by a broad, naked pad. The eyes and ears are small: the latter are rounded, with little trace of tragus or antitragus, densely clad with hair within and without, and almost buried in the fur. The **hands** are relatively short but quite broad; their palms are naked, and for the greater part occupied by a pair of large, rounded pads, which fuse centrally and represent the posterior carpal pads of other rodents; there is little distinct trace of the anterior pads normally present; the digits, of which 3 and 4 are the longest, are short and armed with long, slightly curved, and rather flattened claws. The well-developed thumb bears a claw like those of the fingers. The **feet** are very large, about two and a half times as long as the hands, with broad, naked, scaly, and wrinkled soles, the pads being practically obsolete; each has five long toes, united by a strong web which extends to the bases of the claws; the latter are in general like those of the hand, but are especially large on digits 3 and 4; the claw of digit 2 is "double," a peculiar laterally compressed supplement springing from the ball of the toe beneath the claw proper and rivalling the latter in size; digit 4 is the longest, slightly exceeding 3 and 5. The **tail** is of exceptional strength, and highly modified as a swimming and steering organ; it is very broad

the summer of 1893, and so exposing the entrances to the burrows in the banks, were purchased by the Zoological Society of London; of them six lived for some time in the Gardens at Regent's Park (*Proc. Zool. Soc.*, 1893, 612). Cocks informs us that these would not eat the rations usually supplied to the Canadian Beavers. Cocks has further kindly called our attention to a paragraph in the *Times* (30th December 1913), stating that a local sportsman had killed a Beaver near Dijon. If this example does not point to the existence of an inland colony, previously overlooked, then it must have followed the Rhone, and its continuation the Saone, for more than half the length of France.

[1] Lankester, *Ann. Mag. Nat. Hist.*, 1864, 355; Newton, *Pliocene Vert.*, 1891, 50; and Hinton, *Ann. Mag. Nat. Hist.*, January 1914, 186.

[2] Forsyth Major, *P.Z.S.*, 1908, 630; Hinton, *Ann. Mag. Nat. Hist.*, January 1914, 188.

and flat, its greatest width (about half-way down) equalling about one-third of its length; at its base it is densely furred, but elsewhere its covering consists of large, flattened scales, between which are scattered a few short, stiff hairs. The urino-genital organs, anal glands, and anus open into a cloaca, so that apart from the mammæ, of which the female has four, the sexes look alike externally.

The **pelage** consists chiefly of a very dense, long underfur (about 25 mm. long on back), with a far scantier growth of long, coarse hairs (50 to 60 mm. long); the latter are more abundant on the back, where they nearly conceal the underfur, but towards the flanks and on the underside they are more scattered, and leave the underfur plainly visible. The upper surfaces of the hands and feet are clothed with short hair, which completely conceals the scales.

The general **colour** of the head and body is a lighter or darker yellowish-brown, imparted chiefly by the longer hairs: the tint is usually duller below than on the back, and greyer or more pallid about the face and chin; the hairy parts of the hands and feet are brown; the naked muzzle pad, soles, palms, and the scaly portion of the tail are dusky. Partly or wholly albinistic specimens are sometimes met with, and their skins have sometimes a beautiful, iridescent lustre.

In addition to the family peculiarities described above, the strongly-built **skull** is characterised by the remarkable cellular excavation of the ventral surface of the basioccipital. The auditory bullæ are small, and each has a very long, tubular or spoutlike, external meatus. The zygomatic arches are very strong and widely expanded. The anterior palatal foramina are short and narrow; the tooth-rows are anteriorly convergent, and the pterygoid fossæ are deep, the short alisphenoid canals opening into their outer margins. The nasals taper posteriorly and terminate in the interorbital region well behind the ends of the ascending branches of the premaxillæ; in the American Beavers the nasals are shorter and terminate posteriorly at the level of the lachrymals.

The **mandible** is strong and deep; its rami are very firmly connected with each other: the strong coronoid processes rise considerably above the rounded condyles; the angular processes are rather small, and their posterior tips rise above the level of the cheek-teeth.

Dentition:—Both the incisors and the cheek-teeth when unworn show traces of a former, primitive, tubercular or brachyodont structure. The tips of quite unworn incisors are very slender, rounded, and coated on both their anterior and posterior surfaces with enamel; they show more or less distinct traces of apical tubercles and of grooves, which appear to represent the valleys which originally separated the incisor cusps; such parts are, of course, wholly ephemeral, and as vanishing structures betray a high degree of individual variability.

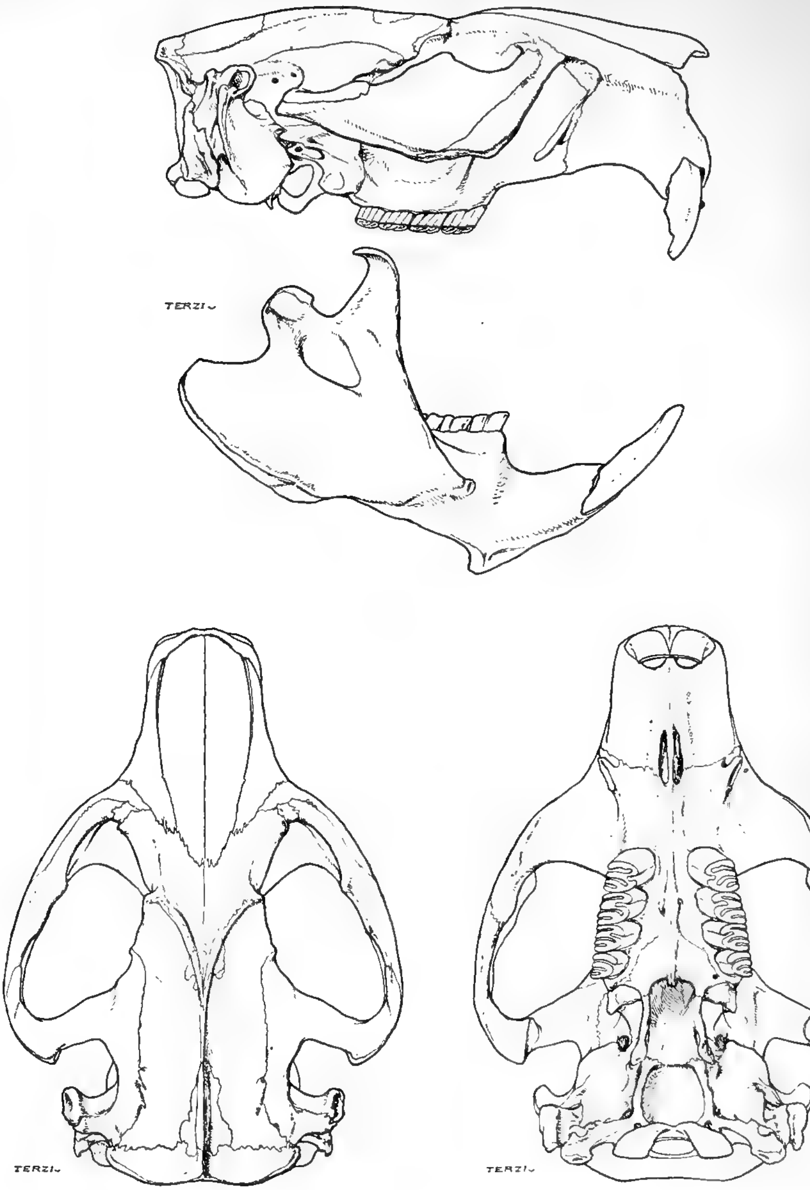


FIG. 96.—SKULL OF BEAVER (half life size).

Reproduced from Miller's *Catalogue of Mammals of Western Europe*, by the kind permission of the Trustees of the British Museum (Nat. Hist.).

The young incisor widens rapidly towards the pulp cavity; at a few millimetres from the unworn tip, the posterior enamel dies out, that of the anterior surface alone persisting; when wear reaches this point the chisel-like cutting edge, so characteristic of the adult incisor, is speedily produced. The milk-molars are in the general form of their crowns and roots strongly reminiscent of the teeth of more primitive Sciurids—and indeed of those of other ancient rodents, *e.g. Titanomys* among the *Lagomorpha.* They and the permanent cheek-teeth have, when quite unworn, tubercular caps; as the coronal tubercles wear away the prismatic structure of the deeper tooth-levels is revealed. In adult stages of wear the crowns of the cheek-teeth are squarish, the upper teeth being slightly broader than long, the lower rather longer than broad. Each upper tooth has typically three narrow re-entrant enamel folds starting from the outer border, and a single wider fold from the inner side. In lower teeth the pattern is similar, but the arrangement is reversed, the three narrow folds being internal, the single wider one external. All the folds persist until a very advanced stage of wear has been reached. The enamel is smooth and uncrimped, although, in aged specimens, a moderate plication sometimes appears in one or other of the folds. Short roots are developed late in life.

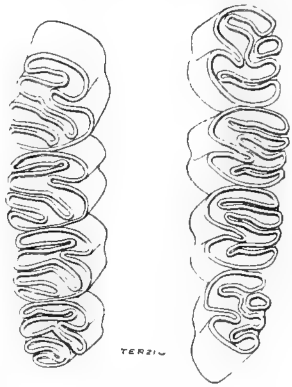


FIG. 97.—CHEEK-TEETH OF BEAVER ($1\frac{1}{2}$ times life size). Reproduced from Miller's *Catalogue*, by permission of the Trustees of the British Museum (Nat. Hist.).

Dimensions in millimetres of skull:—Adult, Mildenhall, Suffolk, Alluvium (B.M. 85.8.4 1)—Condylo-basal length, 142; zygomatic breadth, 106·4; interorbital constriction, 30·4; mastoid breadth, 69; occipital depth, 42·8; length and greatest width of nasals, 61·4 × 29; diastema, 48; maxillary tooth-row, 33·6; mandible, 109; mandibular tooth-row, 36·8.

Status:—*C. fiber* is now extinct in Britain. Attempts have been made to introduce the Canadian Beaver, and these have succeeded in showing that there is no serious difficulty as regards the possibility of acclimatisation. The Marquess of Bute introduced Canadian Beavers to Bute in 1874 and 1875; the colony, although now extinct, was in a thriving condition for a good many years, and the keeper, Mr J. S. Black, published an interesting account of it (*Journ. Forestry*, February 1880); this account has been fully quoted by Harting (*Extinct Brit. An.*, 52). Some were turned down at Sotherley Park, Wangford, Suffolk, but their dams were destroyed as an eyesore, and the last seems to have been killed about 1872 (Harting, *op. cit.*, 59). More

recently Sir E. G. Loder has established a beaver-pond on his estate at Horsham, Sussex (*P.Z.S.*, 1898, 201), and this colony is still thriving.[1]

[Genus TROGONTHERIUM.

1809. Trogontherium, G. Fischer von Waldheim, *Mem. and Soc. Imp. Nat. Moscow*, ii., 260; Owen; Newton.

1823. *Castor*, G. Cuvier (in part); 1848, *Diabroticus*, A. Pomel; 1862, *Conodontes*, Laugel.

TROGONTHERIUM CUVIERI, Fischer.

1823. Trogontherium cuvieri, G. Fischer in Cuvier, *Rech. Oss. Foss.*, ed. 2, v., 59, based on a skull from sandy deposits of uncertain age near the Sea of Azof; Owen; Newton.

1823. Castor trogontherium, G. Cuvier, *Rech. Oss. Foss.*, ed. 2, v., 60.

1848. Diabroticus schmerlingi, A. Pomel, *Biblio. Univ. Genève Arch. Sci.*, ix., 167.

1862. Conodontes boisvillettei, Laugel, *Bull. Soc. Géol. Fr.* (2), xix., 709.

The largest British rodent, although long extinct, deserves a brief notice here. Fischer based his genus *Trogontherium* upon a fossil skull found in a sandy deposit exposed near the Sea of Azof. On the basis of drawings of this skull, sent to him by Fischer, Cuvier was unable to appreciate any generic distinction from *Castor*, although he estimated *Trogontherium* to have been fully one-fifth larger than the largest living Beaver. The subsequent discovery of fine material in English strata (and its able description by Owen and Newton) leaves no room for doubting the title of *Trogontherium* to full generic rank.

The dental formula is as in *Castor*. The incisors are much larger and less strongly curved. The cheek-teeth have triangular instead of squarish crowns, and they develop roots at a comparatively early age. The premolars are the largest, and are relatively larger than in *Castor*; m^1 and m^2 are small, while m^3 is somewhat larger, and when little worn is more complex. In the Beaver the cheek-teeth decrease in size progressively from before backwards. While the enamel pattern is essentially similar to that of *Castor*, the infolds soon lose their connection with the periphery of the tooth and become reduced to "islets" at relatively early stages of wear. The vertical extension of certain of the folds also is less, and they are soon entirely worn out.

The **skull** differs from that of *Castor* chiefly in that the ventral surface of the basi-occipital shows the normal median ridge and shallow lateral fossæ instead of the peculiar deep pharyngeal pit of the Beaver;

[1] Sir E. G. Loder told Cocks (Jan. 1917) that his Beavers have ceased to breed for several years, but he has now introduced a young pair from the Zoo (keeping them carefully separate, however, from the old ones).

the bullæ are less inflated; the rostrum is stouter; the frontals longer, and their postorbital processes set further back; the parietals shorter; the anterior palatal foramina are nearer to the grinders, and are formed equally by the maxillæ and premaxillæ instead of almost wholly by the latter; the posterior edge of the palate is placed a little further forwards; and the maxillary zygomatic buttresses descend only about halfway down the maxillæ instead of to their alveolar margins (Newton, *op. cit. infra*).

Owen[1] referred some limb bones from the Norfolk Forest Bed, including a femur, tibia, astragalus, and calcaneum, to this genus, and he inferred from these bones that *Trogontherium* was less aquatic than *Castor*, and a swifter mover upon land. Quite recently another bone of the foot—the navicular—has been discovered, and a study of this has led independently to a similar conclusion.[2]

It is further of interest to note that an unworn incisor of *Trogontherium* presents ephemeral complications similar to those observed in *Castor* (p. 679 above); these complications point back to the common but very remote ancestor of all *simplicidentata* which must have possessed brachyodont and cuspidate incisors.[3]

T. cuvieri is known in Britain only from the Norfolk Forest Bed and from the High Terrace (early Pleistocene) of the Thames near Greenhithe, Kent. From the former horizon numerous remains have been obtained, including the magnificent skull found by Savin at East Runton and described by Newton in 1891 (*Trans. Zool. Soc.*, xiii., 165). Elsewhere in Western Europe the species has been met with in the Pliocene of St Prest, France, and in the early Pleistocene of Chelles, France, and Mosbach and Mauer, Germany. Remains of a smaller species, *T. minus*, have been described by Newton from the Red Crag (Pliocene) of Suffolk.]

SCIURIDÆ.

SQUIRRELS AND MARMOTS.

This large family, comprising more than fifty distinct genera and many hundreds of species, is distributed throughout the eastern and western hemispheres with the exception of their polar extremities, Madagascar, New Guinea, and Australasia. As now understood, it embraces all the living

[1] Owen, *Geol. Mag.*, decade 1, vi., 1869, p. 52.
[2] Hinton, *Ann. Mag. Nat. Hist.*, January 1914, p. 190.
[3] Hinton, *op. cit.*, p. 189.

arboreal and terrestrial squirrel-like rodents, but does not include the volant genera, which are placed in a special family—the *Petauristidæ*. For our knowledge of the status of the group and the classification of its members we are chiefly indebted to the work of Winge, Forsyth Major, and Thomas.

In a few respects the family stands on a somewhat higher plane than the *Castoridæ*. Thus the orbits are always partly roofed by the considerable supraorbital processes of the frontals. The auditory bullæ are divided internally by bony septa. The thumbs are in all reduced to short stumps. But apart from these characters and from the remarkable degree of specialisation evinced by the masseter muscles and the skeletal parts under their influence—a specialisation which, as shown above, is common to all Sciuromorpha—the members of this family retain many primitive features which stamp them as, in these respects, the least progressive of the Simplicidentata.

The **dentition** includes typically two functional premolars above and one below on each side, and these are preceded by well-developed and for a time functional milk molars; but in many forms the anterior upper premolar (p^3) is reduced or absent. The cheek-teeth, although showing from genus to genus a wide range of variation in structure, particularly in the degree of their progress towards lophodonty or hypsodonty, are always of a brachyodont type and are implanted solely by their distinct roots. In the **skull** the jugals are always large, articulating in front with the lachrymals; the bodies of the maxillaries are always shallow; and where least modified, as in the African *Euxerus* or the Asiatic *Eutamias*, the brain-case retains a form which recalls that of the least modified *Hystricomorpha*. The upper incisors extend backwards into the maxillæ, but terminate distinctly in advance of the premolars; the lower incisors terminate in the ascending rami of the mandible, but little above the molar level.

In the **skeleton** there are twelve or thirteen pairs of ribs; a well-developed clavicle; and the fibula is distinct from the tibia and does not articulate with the calcaneum. There is a well-developed *os penis;* Thomas, who calls this bone the *baculum*, has recently shown it to be subject to great and

surprising variations of form within the limits of the old genus *Sciurus;* and the modern classification of this unwieldy group, now developing, will no doubt largely rest upon the characters afforded by this organ (*Ann. Mag. Nat. Hist.*, April 1915, 383).

The family dates from the Upper Oligocene, at least, in Europe and North America. Apart from some Sciurid remains from the Oligocene of Wight, which appear to represent a forerunner of *Sciuropterus* rather than a member of the present family, its British representatives belong to two genera, *Sciurus* and *Citellus;* both of them are members of the sub-family *Sciurinæ*. *Citellus* is only known from our Pleistocene deposits; but *Sciurus* has still a representative living in these islands.

Genus SCIURUS.

1758. Sciurus, C. Linnæus, *Syst. Nat.*, 10th ed., i., 63; genotype *vulgaris*, selected by tautonymy.

1893. Aphrontis, Schulze, *Zeitsch. f. Naturwissensch.*, Leipzig, lxvi., 165; based on *Sciurus vulgaris.*

Squirrels of arboreal habits, whose general external appearance, cranial, dental, and other internal characters are closely similar to those of the well-known European and British species, are widely distributed throughout the wooded parts of Eurasia and the New World. They represent a very large number of species; and until quite recently all have been referred to the genus *Sciurus*. The latter indeed had swollen to such embarrassing dimensions that Miller found it "impossible to frame a satisfactory diagnosis of the genus *Sciurus*, or to estimate the number of forms that should be referred to the group."

Thomas (*op. cit.*, p. 384) describes the baculum of *S. vulgaris* (including *S. leucourus*) as being a "very characteristic bone, like a small spatula, or still more like a half-closed human right hand, the shaft forming the fore-arm, the blade of the spatula the hollowed palm, and a small pointed projection on the right side corresponding to an outstretched thumb." Bacula of this type are found also in the two other Palæarctic species—*S. persicus* and *S. lis;* in all the American species—

so far as Thomas has been able to examine them in this respect; and "remarkable to say" in the Giant Squirrel (*Reithrosciurus*) of Borneo. In all the Indian and Malayan species the baculum is more complex, being provided with a more or less well-developed, separate cutting-blade, articulated with and attached to the shaft of the bone by ligaments; Thomas has therefore removed all these arboreal squirrels from the genus *Sciurus*, reviving Gray's *Callosciurus* for one section, and instituting his own genus *Tomeutes* for another.

A few weeks after the publication of Thomas's paper, Allen (*Bull. Amer. Mus. Nat. Hist.*, xxxiv., May 1915, p. 171), reviewing the South American *Sciuridæ*, removed "the genus *Sciurus* from the American biota" and referred all American squirrels to other generic divisions. Whether such a drastic course is quite justified may be open to some question; but as to its convenience there can be none.

The genus *Sciurus*, as understood at present, therefore comprises merely four living species, viz., *S. vulgaris*, ranging through the whole of Europe and a large part of northern and central Asia; *S. leucourus*, inhabiting Britain and Ireland; *S. persicus*, from Asia Minor and Persia; and *S. lis*, an inhabitant of Japan. In addition several European fossil species, dating from the Eocene onwards, are at present referred to "*Sciurus*"; but in their case the generic name is merely a confession of ignorance; for the fossils hitherto found, although ample to demonstrate the former existence of species with jaws and teeth more or less similar to those of living *Sciurus*, are wholly insufficient as a basis for determining the fine generic distinctions of modern mammalogy.

The leading **characters** of the genus *Sciurus*, as defined above, may be summarised as follows:—Squirrels of essentially arboreal habits, medium size, and typical outward appearance; with a bushy, vertically compressed tail, whose length exceeds half the length of the head and body. The **baculum** is simple, as above described. The **skull** is deep, with a well-arched and relatively capacious brain-case, and a short rostrum; the supra-orbital outgrowths are large and terminate behind in slender postorbital processes. In the **dentition** the incisors are strongly compressed, much deeper than broad in transverse

section. The cheek-teeth are tubercular, brachyodont, and rooted. In the upper jaw, the anterior premolar (p^3) is very small and simple, and has little functional importance; the other teeth ($p^4 - m^3$) are subtriangular in form and have two low rounded tubercles (4 and 5), each supported by a slender root, on their outer borders; with these tubercles are more or less evident traces of the cusps 1, 2 and 3; on the inner side of each tooth is a single relatively lofty cusp, formed by the fusion of at least three elements, and supported by a long and stout root; the base of this inner cusp is connected by low transverse ridges with the bases of the outer cusp 4 and 5; and these transverse ridges form the forward and backward margins of a spacious and rather deep central valley. The lower cheek-teeth ($p_4 - m_3$) are quadratic and four-rooted; each has two low rounded tubercles on the outer side; a shallow basin-shaped concavity occupies the greater part of the surface of the crown; the inner margin of the basin is crenulate behind but anteriorly it rises up into a lofty terete cusp. When the teeth are fitted together, the prominent inner cusp of each upper molar is seen to work in the basin-shaped concavity of the opposing lower tooth like a pestle in a mortar; while the lofty antero-internal cusp of each lower molar shears within and between the internal cusps of two contiguous upper molars. As explained by Forsyth Major (*Proc. Zool. Soc.*, 1893, 181), squirrels with cheek-teeth like those of *Sciurus* may be regarded as representing, in the molar evolution of the *Sciuridæ*, an intermediate stage, which connects the most brachyodont forms (*e.g.*, the Eocene *S. spectabilis*, Major, the living *Reithrosciurus* of Borneo and *Protoxerus* of Africa) with the most hypsodont groups (the Ethiopian *Xerus* group, and the Oriental *Menetes* and *Rhinosciurus*).

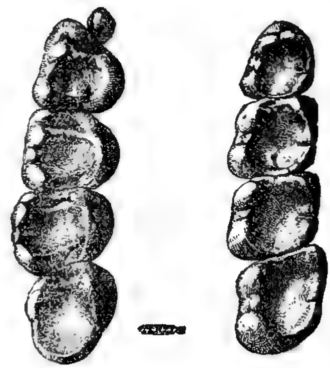


Fig. 98. — Cheek-Teeth of Squirrel (*Sciurus vulgaris*). × 5. Reproduced from Miller's *Catalogue*, by permission of the Trustees of the British Museum (Nat. Hist.).

THE BRITISH OR LIGHT-TAILED SQUIRREL.

SCIURUS LEUCOURUS (Kerr).

1769. SCIURUS VULGARIS, John Berkenhout, *Outlines Nat. Hist. Great Britain and Ireland*, i., 6; and of most subsequent writers up to and including Thomas, *Zoologist*, 1898, 100, but not *S. vulgaris* of Linnæus.

1792. SCIURUS VULGARIS LEUCOURUS, Robert Kerr, *Animal Kingdom*, 256; described from England; Miller, *Catalogue Mamm. West. Europe*, 907.

1899. SCIURUS LEUCURUS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 17th January 1899, 3; Millais; Trouessart (sub-species of *vulgaris*).

L'écureuil of the French; *das Eichhörnchen* of the Germans; these, with, no doubt, many local names in each language, strictly refer to the nearly allied continental species *S. vulgaris*, and not to the present animal at all.

The quite simple **synonymy** of this animal is due to its differentiation from the Common Squirrel of continental Europe, *S. vulgaris* of Linnæus, an animal which, through its numerous sub-species, has accumulated a host of technical names.

Terminology:—"Squirrel," with many variations in spelling, has been the general name of this animal from the Norman Conquest. The Middle English form is "squirel" or "scurel"; *e.g.*, Wright's *Vocabulary*, 759, 29:—"*Hic scurellus*, a scurelle." (Chaucer *Rom. of the Rose*, 1471) has—"There might menne does and roes ysee, And of squirrels full great plentee, From bough to bough alway leping"; and again (*Parl. Foules*, 196) he speaks of "Squirrels, and beastes small of gentle kind." The word appears to have been derived from the Norman French *esquirel;* this and the Old French *escurel*, *escuirel* and *escuireul* (in thirteenth century, *MS.*, *Cocks*) came from the late Latin *scurellus* or *scuriolus*, diminutives of the Latin *sciurus.* The latter is derived from the Greek σκίουρος, the literal meaning of which is said to be "shadow-tail"—though this is probably due to popular etymology, the real origin of the name not having been certainly found.

According to Somner (*Dict. Saxonico-Lat.-Angl.*, 1659; quoted by Bosworth, *Anglo-Saxon and Engl. Dict.*, 1868, 20), the Anglo-Saxon name for the Squirrel is *Acwern;* Bosworth (*op. cit.*, 251) also gives *wern*, without the prefix *ac.* *Acwern* appears to be the equivalent of the German *Eichhorn*, the Danish *Egern*, and the similar names in other Teutonic languages. In each of these cases the prefix means oak-tree; but, as Keller (*Die Antike Tierwelt*, 181) points out, the animal has no particular love for the oak, and the real etymology is unknown. As regards *acwern*, if *ac* may once have signified "tree" in general,[1] rather than oak in particular; and if *wern* can be derived from the Anglo-

[1] For a discussion of the changes in meaning of the names "fir," "oak," and "beech" in various languages, see Max Müller, *Lect. on Science of Language*, ser. 2, 1864, 216, 219, and 222.

Saxon *wær*="wary," or *wærgenga*, which means "one who retires to lonely places, such as a wild beast," then the compound *acwern* might signify literally "the animal which takes refuge in trees."

Local names:—(Non-Celtic)—*Scopperil* of Yorkshire; thus "He went up the tree loike a scoperil" (*Yorks. Weekly Post*, 12th June 1897). The original meaning of this word is given by Wright as a spinning-top or teetotum. It is a Skandinavian word and a diminutive formed from "*skop*," the root sense of which was the "skipper" from *skopa*, to skip, of the Swedish (dialect), or "spinner" from the Icelandic *skoppa*, "to spin like a top." The form *scoperil* was corrupted into *scropel*, also a Yorkshire form given by Wright; *e.g.*, "I can hear th' boggarts creeping, wick as scropels, fro' roof to cellar" (Sutcliffe, *Shameless Wayne*, 1900, vii.).

Scrug of Hampshire (Wright) with its corruptions *scug*, *skug*, or *skugg*, appears also to be of Skandinavian origin; this name, in one form or another, is in very general use throughout the greater part of England, and Benjamin Franklin has recorded the fact that in his day *skugg* was the common name for all squirrels in London.

Swirrel, *sweril*, and *swirl* of the northern dialects are, of course, merely variants or corruptions of squirrel.

Con, or *conn*, is a name found in the northern dialects; the earliest reference cited in the *New Engl. Dict.* is to Burel's *Pilgremer* (in Watson, *Coll. Poems*, ii., 20), dating from 1600, in which are the lines:—"There wes the pikit porcupie, The cunning & the con all thrie." Harvie-Brown states that the word is, or was, used in north Lancashire, southern Cumberland, Westmoreland, and through the south of Scotland; he says that the word is unknown in the north of Cumberland, and cites Ferguson, who gives (*Dial. of Cumberland*) "*con*, a squirrel's nest; in Lonsdale, the squirrel," and who refers it to the Welsh *cont*, a tail. Harvie-Brown further states that the word is now quite extinct in southern Scotland, although it was known to Alastair M'Donald, who, in 1771 translated the Gaelic *feoirag* as "a squirrel or *conn*." According to Harvie-Brown, Gaelic scholars are of opinion that the word is a contraction of the Gaelic *coinein*, a rabbit, which they think is a diminutive of *cu*, a dog. But, as the quotation from Burel given above shows, early writers distinguished the *con* from the *cuning*.

The nest of the squirrel is called a *dray*, *drey*, or *drug* in many of the southern and midland counties of England (see White's *Selborne*, Bennett's ed., 1837, 460[1]). This word is of uncertain origin, but may have been derived from the Anglo-Saxon *dragan*, to draw.[2] According-

[1] In footnote 2 to the page cited, Mitford states that the nest is called a *bay* in Suffolk.

[2] We would suggest a possible derivation from the Anglo-Saxon *drig*, *dreg*, *drug*, or *dryg*=dry; the *dray* being the place where the squirrel keeps high and dry.

ing to the *New Engl. Dict.* it first occurs in Topsell, who mentions "the draies of squirrels."

(Celtic):—Irish—*Feoróg* (MacBain); *Iora* or *Ir* (the latter obsolete according to C. M. Robertson); *Easag* or *Easog* (MacBain); "*Crichdran*" (? *Craobharan*).

Scottish Gaelic:—*Fheòrag* or *feórag*; *Easag* (C. H. Alston).

Welsh:—*Gwiwair* (Pennant); or better *Gwiwer* (Fisher).

The Celtic names for the squirrel are puzzling and their literal translation difficult. The difficulty seems to arise largely from the fact that squirrels have, at all times and among all peoples, been often confused with martens, weasels, and even with foxes.

Feórag (with its variants) may be translated as "the little inquisitive one"; but if it has been derived from *fhiodarag* it would signify merely a "wood- or tree-animal." *Iora* and *ir* also indicate the inquisitive nature of the animal, and O'Mulrennan (*fide* Warren, in Harvie-Brown, *MS.*) was inclined to explain *feórag* as a derivative—*f-iorag*—*f* being prefixed, in accordance with the common Celtic practice of prefixing *f* to a word commencing with a vowel, and the diminutive *ag* being suffixed.

Easag, or *easog*, is perhaps more properly applicable to mustelines; for in Irish *easag* is the name of the Stoat, while *easag-cram* signifies the "tree-weasel" or Marten. But no doubt *easag* has often been used for the squirrel and it is used for pheasants as well.

"*Crichdran*" appears in the list of wild animals produced before the king at Tara, as the ransom of Finn MacCumhaill, given in a *MS.* poem dating from before A.D. 1000 (see Wilde, *Proc. Roy. Ir. Acad.*, vii., 181). The word "*crichdran*" appears to be unknown in either Irish or Scottish Gaelic; but James Macpherson (*fide* Harvie-Brown) thought it to be possibly a mis-reading of *craobharan* or "the tree-animal."

Distribution:—This Squirrel is confined to the British Islands, where it is common in all wooded localities of Great Britain, except only those in which its numbers are kept in check by persecution. Where there are no woods it is absent, and it disappeared almost from Scotland, and entirely from Ireland. But it soon appears in newly planted districts, and has been reintroduced in both the last-named countries. It is increasing in the newly wooded districts of Wales, where it is common up to 1000 feet (Forrest), and ascends to 1400 feet in Aberdeen (Dickie).[1] It comes quite close to towns, and may even enter public gardens connected with them.

Its **status** in **England** requires no special comment, except as regards Cornwall and "Lakeland." In the former it is stated to be extending its range. Although abundant throughout the Truro and

[1] Dickie, *Botanists' Guide to Aberdeen, Banff, and Kincardine*, 1860; quoted by Harvie-Brown, *op. cit. infra*, 151.

Falmouth district, it seems to be absent from the west and south-west, as well as from many parts of the east and north (Clark). In Lakeland, Macpherson seems to suggest that it may not be indigenous, and Tate says that it is of comparatively modern reintroduction in many parts of the north of England (*Proc. Berwickshire Field Club*, i., 440). But Macpherson admits that a little more than a hundred years ago it was certainly well established in Lakeland, that it is represented in armorial bearings of the county families, as well as on the Runic Bewcastle Cross, and that its skin was known in commerce at Berwick in 1377; the skins, however, may have been imported. It is common in plantations in Anglesey and Wight.

Its distribution in **Scotland** has been investigated by Harvie-Brown, whose lengthy and erudite paper[1] on the subject is difficult to summarise. According to this writer there is no record of its existence as an indigenous animal south of the Firths of Forth and Clyde, other than two vague allusions in the *New Statistical Accounts of Berwickshire* (p. 299, 1841) and *Roxburghshire* (p. 4, 1841). To these must be added the statement of Sibbald in 1684 (*Scotia Illustrata*, 2, ii. 11), that it occurred *in meridionalis Plagæ Scotiæ Sylvis*, a statement which Harvie-Brown appears to consider as in itself of little or no value. Even, however, if Sibbald's statement be accepted, as it is by W. Evans, the animal must have practically disappeared in the lowlands soon after Sibbald's time, retiring to or lingering in the shelter of the forests north of the Firths of Forth and Clyde. North of these Firths, as shown by the records, it appears to have been widely spread in the Middle Ages, and was found by Sir Robert Gordon in 1630 even in Sutherland (*History of Earldom of Sutherland*, 1630, not printed from MSS. until 1813). Subsequently, however, it became very rare, if not extinct, in the greater part of the country, succumbing to the universal destruction of forests, which banished also the roe-deer and capercailzie. But there is every reason to believe that it lingered on in one or two favoured localities, as in Ross-shire, to the end of the eighteenth century, and in Ayrshire to about 1839 or 1840. In the great old forest of Rothiemurchus it probably never became entirely extinct, so that a remnant of the true ancient Scottish race issued thence to colonise the new woods and plantations. Finally, in the eighteenth and nineteenth centuries, it was reintroduced from England in many centres, as notably at Dalkeith, Midlothian, about 1772, by Elizabeth, Duchess of Buccleuch (W. Evans); and with the growth of plantations has now gradually spread over the whole mainland, having re-entered Sutherland about 1869 (Alston and Harvie-Brown, *Proc. Nat. Hist. Soc., Glasgow*, ii., 144) and South Ayrshire in 1877 (see Alston; Harvie-Brown, vi., 35;

[1] J. A. Harvie-Brown, *Proc. Roy. Phys. Soc., Edinburgh*, v., 343; vi., 31 and 115.

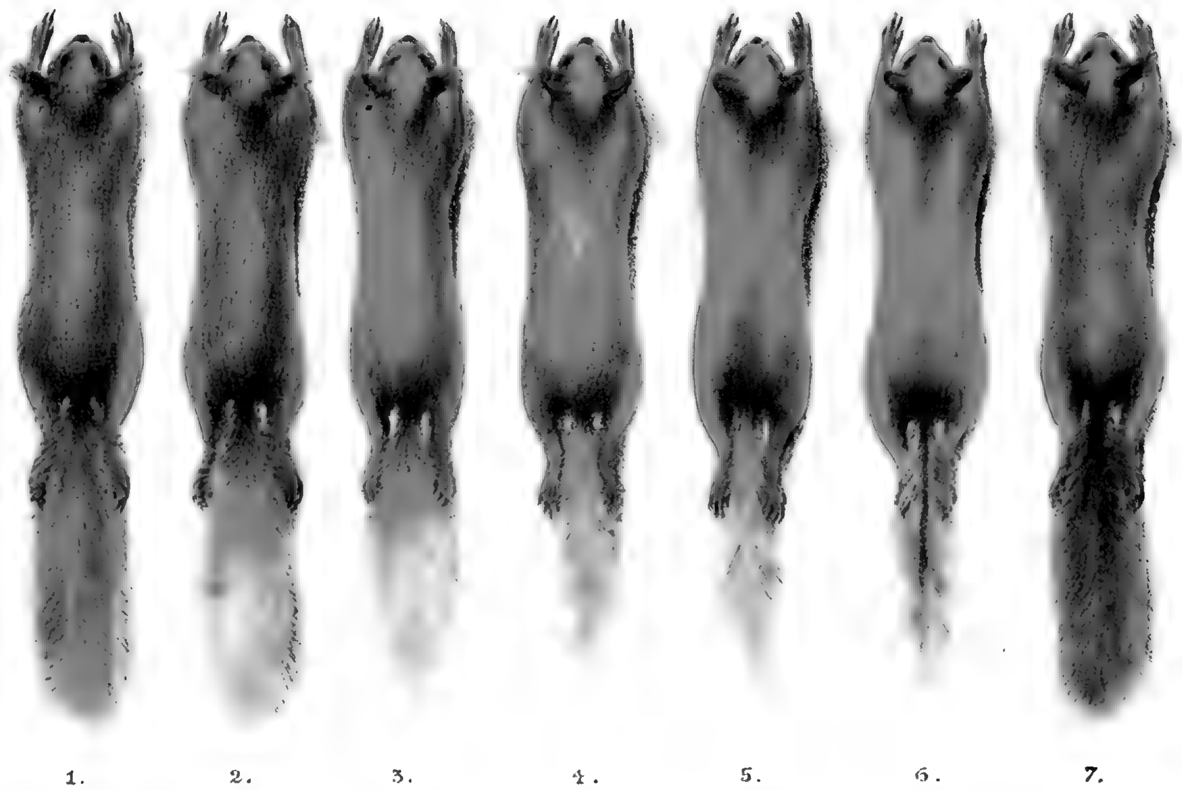
W. Evans). Perhaps in some cases introductions were made from Continental Europe (Harvie-Brown, vi., 148); but such continental squirrels would have, of course, been *S. vulgaris*, of which no Scottish example has been identified.

In **Ireland** it is now widely distributed, and common in a number of localities in many counties; but Barrington (*Sci. Proc. Roy. Dublin Soc.*, November 1880, 615-631) has shown that its presence may in all cases be traced to introductions, none of which took place earlier than about 1815. He could find no trustworthy evidence of the presence of the animal in Ireland before the nineteenth century, and believed that it could not have been indigenous.

The following twenty counties were scheduled by Barrington as harbouring Squirrels in 1880:—Wicklow, Dublin, Kildare, Wexford, Carlow, Kilkenny, Queen's, King's, Galway, Roscommon, Longford, Westmeath, Donegal, Antrim, Tyrone, Monaghan, Londonderry, Down, Armagh, and Louth. At that time there was no evidence of their occurrence in the remaining twelve counties of Fermanagh, Leitrim, Cavan, Meath, Sligo, Mayo, Clare, Limerick, Kerry, Cork, Tipperary, and Waterford.

Since 1880 Squirrels have vastly extended their range in Ireland, helped no doubt by further introductions—as in Wexford, where they were introduced near New Ross, and have, besides, entered the north of the county from Co. Wicklow, overrunning it in two directions until their two forces met. Further they have colonised a new county—Waterford — where they were reported to Barrett-Hamilton from Faithlegg in 1896 by Ussher. Adding Tipperary, in many parts of which they are plentiful, they are now in occupation of the whole south-east of Ireland. About the year 1895 they were seen at Glasslough, Co. Fermanagh (James Brodie, Keeper, *in lit.*, 30th January 1895), as well as at the Deeps (Col. C. S. Walker, *in lit.*, 21st April 1896), and at Edermine (Sir J. Power, *in lit.*, April 1898), the two latter localities being in Wexford. By the same date they had quite overrun Co. Meath (Rev. J. B. Gibson, *in lit.*, 26th December 1895). They have also appeared in the west, having been reported from Kerry (Jenner, *Field*, 24th October 1908, 721), and there can be no doubt that their presence may be confidently expected in the immediate future in all the wooded parts of Ireland.

Although Barrington could not have justifiably decided otherwise on the evidence which he had before him, there are now available a number of records pointing to the presence of the Squirrel as an indigenous member of the Irish fauna in historical times, and thus confirming the suggestion made previously by Harvie-Brown (*op. cit.*, p. 80). In the numerous lists of the exports of Ireland which have now been published, and which date from the earliest times for



Skins of British Squirrel—*Sciurus leucourus.* Seasonal Change.

1. January. 2. March. 3. May. 4. June. 5. July. 6. September. 7. November.

which we possess any information, even from before the Norman Conquest, furs and skins always hold a prominent position (*Sinn Feinn*, 1908, 130-138). The names of these are given in some detail, and we find that of the Squirrel included, besides Horse, Ox, Sheep, Lamb, Deer, Wolf, Marten, Otter, Wild Cat, Hare and Rabbit (*op. cit.*, 130; also Mrs Green's *The Making of Ireland and its Undoing*, 1908, 73).

In the thirteenth century there are several allusions to a tax on Squirrel skins, as at Waterford, where in 1243 the citizens were allowed customs for walling the town, including those on the skins of Squirrels (*Cal. Doc., Ireland*, i., 2613). A similar grant was allowed to the men of Drogheda in 1278 (*op. cit.*, ii., 1517), of Cork in 1284 (*op. cit.*, iii., 520), of Fethard in 1292 (*op. cit.*, 1015), and again of Waterford on 28th June 1291 (*op. cit.*, 917).[1] On 28th April 1286, Thomas Fitzmaurice was granted customs to enable him to wall Tralee and Moyal (Mallow); these customs included a tax of one halfpenny on every hundred skins of squirrels (*Proc. Roy. Soc. Antiquaries, Ireland*, xxiv., 16). Quite three quarters of Ireland are thus represented, and the records indicate a wide distribution, including the whole island except the north and north-west.

At that period the fur of the Squirrel was used for trimming the robes of superior Irish officials, as mentioned by Froissart in describing the visit of Richard II.; and Barrett-Hamilton was informed by Captain Philip Hore, the well-known author of the *History of County Wexford*, that the records of the reign of Edward I. (1272-1307) include many notices of the prices paid for the skins, which are clearly distinguished from those of the Marten and "Weazil."

A particular use of the fur of the Squirrel may be cited from the accounts of the Lordship of Carlow, made out between 1279 and 1284 for the owner, Roger Biford, Earl of Norfolk, who died in 1306 (see James Mills, *Proc. Roy. Soc. Antiquaries, Ireland*, April 1892, 50-56). So well-known was the fur that it had two distinct names, being called "Strangling,"[2] when at its best as between Michaelmas and winter, and "Roskyn," perhaps from its russet colour, in summer.

There is a comprehensive list of the fur-bearing animals of Ireland and its other natural products in the *Libel of English Policie*, written

[1] For many references Barrett-Hamilton was indebted to the kindness of T. J. Westropp, who met with them during his studies of Irish History.

[2] A name also known in Scotland (variously spelt as "Strandling," "Strandeling," "Strandlyn," "Stranling," or "Stradling") in 1328 and 1329; see Harvie-Brown, *op. cit.*, vi., 38. One might hazard the suggestion that "Strandlings" signified "skins coming from beyond the seas," and that the term was equivalent to the "Calabar" of modern furriers.

about 1430, and dealing with the trade of Chester. The passage may be quoted *in extenso*:—

> "I caste to speke of Irelonde but a lytelle,
> Commoditees yit I woll entitelle,
> Hydes, and fish, samon, hake, herynge,
> Irish wollen, lynyn cloth, faldynge,
> And marternus gode, bene here marchandyse,
> Hertys hydes, and other of venerye,
> Skynnes of otere, squerel, and Irysh hare,
> Of shepe, lambe, and fox, is here chaffare,
> Ffelles of kydde and conies grete plente,
> Of silver and golde there is the oore."[1]

At about the same time one Nicholas Arthur of Limerick is definitely mentioned as trading in horses, falcons, skins of otters, martens, squirrels, and other soft-furred animals (*Arthur. MSS.*, Lenihan, Limerick, 369), his first trading voyage having taken place in 1438. Finally, in the late fifteenth century, the skin of the Squirrel was included by Hakluyt amongst the exports of Ireland.

The above records are ample and conclusive as to the former existence of the Squirrel in Ireland. They are quite satisfactory on all the points which might have been subject to error, *e.g.* there is no possible confusion with any other animal, and the export and import trades are not confused, a matter of importance when it is remembered that there was in mediæval times a considerable import trade in Squirrel skins.

Exactly when the animal became extinct is still a matter of conjecture, but, since it must have previously reached a point at which its pursuit became unprofitable, documents may at any time be discovered throwing light upon it. In the meantime there is little to bridge the gap between the end of the fifteenth century when the squirrel must have been abundant and its reintroduction about 1815. Its inclusion in O'Flaherty's list of the animals of Western Connaught in 1684 and in Keough's *Zoologica Medicinalis Hibernica* (p. 83) in 1739 are, if unsupported, records of quite doubtful value. Certainly, however, they gain in authority from the other records by which they are now known to have been preceded; but it would probably be unsafe to argue from them, as some do, that these two records indicate that the Squirrel never became altogether extinct in Ireland.

Apart from the persecution of man, the cause of the disappearance of the Squirrel from Ireland must always remain doubtful. But the universal destruction of woods, into the remnants of which the beasts

[1] *Political Songs* (Rolls Series, ii., 185, 1861): reprinted at p. 414 of *Ireland, Industrial and Agricultural*, published by the Department of Agricultural and Technical Instruction for Ireland, Dublin, 1902; also in Joyce, 433.

of prey—stoats, martens, and perhaps wild cats—must have gathered in unusual numbers could have had no small influence.

The Squirrel is absent from Man (Kermode in Ralfe) and all the Scotch Islands, except Bute, where it is said to have been introduced about 1873 (Harvie-Brown), but is now extinct.

Distribution in time:—Notwithstanding the great antiquity of the genus, it appears to have left but few traces of its former existence in the fossiliferous deposits of Britain. Apart from the early Tertiary remains noticed above, our knowledge is limited to the scanty information gleaned from the late pliocene Norfolk "Forest Bed." Heer first noticed that some fossil fir-cones from this deposit appeared to have been gnawed by Squirrels (Lyell, *Antiq. of Man*, 1863, 215). Later, Newton (*Vert. For. Bed.*, 92) ascribed a humerus in the Green collection (British Museum) to *S. vulgaris;* this specimen is reputed to be from the Forest Bed of Ostend, Norfolk, but its age, as Newton pointed out, is quite doubtful, there being a much more recent alluvial deposit in the vicinity from which Green also collected many specimens. Quite recently, however, a premolar has been found in the Forest Bed at West Runton, and this proves the late Pliocene species—*S. whitei*, Hinton (*Ann. and Mag. Nat. Hist.*, January 1914, 193)—to have had a more bunodont and primitive dentition than *leucourus* or *vulgaris;* when better known, *S. whitei* will very likely prove to belong to a genus distinct from *Sciurus* in the strict modern sense. No trace at all of the genus has been so far discovered in the British Pleistocene, a fact to be ascribed to its arboreal habits, and the consequent remoteness of the chance of entombment rather than to its absence from our primeval forests. Woldrich has referred some fragments from the late Pleistocene of Zuzlawitz, Bohemia, to *S. vulgaris.*

Description:—The British Squirrel is a slenderly built rodent, characterised in life by its peculiarly graceful and elegant appearance. Its neck and limbs, being much less completely invested in the common integument of the trunk, are more obvious externally, and apparently longer than in *Muridæ.*

The head is moderately large, rounded behind, with a narrow, rather short, but relatively deep rostrum. The muzzle, except at the margins of the nostrils, is hairy; the median walls of the nostrils are narrowly but deeply separated by an upward continuation of the lip-cleft. Besides the whiskers, which are numerous stout, black hairs, of which some surpass the head in length, tactile hairs occur in three positions, viz. (1) above the eyes, where there are two or three long and rather fine black vibrissæ; (2) on each cheek three or four similar black hairs are placed below the eye, on the level of a line drawn from the mouth to the base of the ear; and (3) on the ventral

surface, just in front of the throat, are three strong, light-coloured vibrissæ.

The eyes are large, black, and prominent. The **ears** are erect, long (overlapping the eyes when laid forwards), rather narrow, and with rounded tips; externally they are clothed with abundant long hairs, which, from early winter to late summer, project beyond the tips as conspicuous tufts or pencils; the inner surfaces have a thinner covering of shorter and finer hairs. In each ear the lower portion of the anterior margin is curled backwards above the small tragus; while the basal half of the posterior margin is curled forwards to form a large and strong triangular flap, which conceals the feeble antitragus, and is capable of closing the meatus from without.

Each **hand** has five prominent and cushioned pads: of these three are anterior and relatively small, and are placed between the bases of digits 2 and 3, 3 and 4, and 4 and 5, the median one being more advanced than the others, which are level; the two posterior pads are larger and of square or somewhat rounded form. Of the digits, 4 is distinctly the longest, 3 is slightly shorter, 2 reaches the ball of digit 3, and 5 is very slightly shorter. These digits are long and free, capable of wide-spreading, hairy above, feebly annulated and naked below, and each is armed with a moderately long, sharp, curved, and strongly compressed claw. The thumb is reduced to a minute vestigial tubercle, which is placed beside the postero-internal carpal pad, being scarcely one-fourth of the size of the latter, and it bears a small flattened nail.

In comparison with the fore-limbs the legs appear disproportionately long and heavy. In each **foot** there are four small pads placed between the bases of the digits; there is no trace of posterior pads. The toes are quite like the fingers in general character, and each, including the hallux, is armed with a long and strong claw; the claws are, however, somewhat stouter than in the hand. Digits 3 and 4 are nearly equal in length, 4 being, however, very slightly the longer; 5 reaches to the base of the ball of 4; 2 is slightly longer than 5; and digit 1 is well-developed, reaching a little beyond the base of 2. Both the palms and the soles are naked in summer typically, the skin between the pads being wrinkled and very finely granular; but with the approach of winter they acquire a more or less dense and extensive covering of short and fine fur.

The **tail** without the terminal hairs is about equal to the body; with the hairs about equal to the body and head in length; it is cylindrical and smooth skinned, not scaly. It is clothed with a dense, woolly underfur, and with very numerous long, soft, but strong hairs, which, rising principally from its back and sides, grow outwards and backwards horizontally, and form a dense bilaterally symmetrical fringe or brush. When fully haired the tail as seen from above or below is strikingly

histories of very many others, which were formerly little known, have been fully elucidated, while, speaking generally, an immense increase in our knowledge on such important subjects as Migration, Distribution, Habits, Nidification, Plumages, has accrued: And lastly, a new and important branch of study has been instituted —namely, the recognition of the various Racial Forms or Subspecies exhibited by certain birds in the British Islands, on the Continent, and elsewhere.

A great advance has also been made towards a more satisfactory system of classification of the Aves—always a difficult subject—and this necessitates departures from the older views.

To bring this Standard Work thoroughly abreast of the most recent knowledge in all these departments is the object of the present work.

It should be remarked that while it is not intended to go fully into Synonomy, yet, where changes of nomenclature have been necessary in order to conform with the Law of Priority—the only method by which complete uniformity in nomenclature can ultimately be attained—the names used in the Fourth Edition of Yarrell's "British Birds" and in Saunders' "Manual," and the Trinomial Names of the British Racial Forms, and of those occurring in Britain as visitors from the Continent, will be quoted, as will also the Original Name under which the species was described.

In requesting Dr Eagle Clarke to undertake the duties of Editorship, the Publishers desire to make it known that they are acting under the advice of the late Mr Howard Saunders, who placed all his collected notes for a New Edition at Dr Eagle Clarke's disposal for this purpose. That Dr Eagle Clarke is eminently fitted for the work is well known to all who are interested in ornithological science. Through his investigations of the subject, and contributions to its literature, he has long been recognised as one of the foremost authorities on all that relates to British birds. He has studied our native birds in many portions of the British Islands, and has visited a number of bird-haunts in various parts of Europe in order to become acquainted in their Continental homes with the visitants that seek our shores.

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PART XXI.—October 1921 **Price 3s. 6d. net.**

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BY

GERALD E. H. BARRETT-HAMILTON
B.A.(CANTAB.), M.R.I.A., F.Z.S.

AND

MARTIN A. C. HINTON
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1921

In Preparation

A NEW AND REVISED EDITION OF
YARRELL, NEWTON, AND SAUNDERS'

HISTORY OF BRITISH BIRDS

EDITED BY

WILLIAM EAGLE CLARKE, LL.D., F.R.S.E., F.L.S.

Late Keeper of the Natural History Department, The Royal Scottish Museum; Member of the British Association Committee on the Migration of Birds as Observed on the British and Irish Coasts; Corresponding Fellow of the American Ornithologists' Union; Correspondirender Mitglied des Ornithologischen Vereins in Wien; Membre Honoraire du Bureau Central Ornithologique Hongrois; Member of the British Ornithologists' Union, etc.

ILLUSTRATED BY ORIGINAL COLOURED PLATES OF EACH SPECIES SPECIALLY EXECUTED BY

MISS LILIAN MEDLAND

THE publication of Yarrell's "History of British Birds" was commenced in 1837 and completed in 1843. Its outstanding merits were at once recognised, and a Second Edition was called for in 1845, followed by a third in 1856.

From the issue of the Original Edition down to the present day, Yarrell's "History of British Birds" has generally and deservedly been regarded as the standard authority on British ornithology.

In the year 1871 a Fourth Edition was begun, under the masterly editorship of Professor Newton—the greatest British ornithologist of all time. Unfortunately Professor Newton's official engagements at the University of Cambridge only allowed him to complete the first two volumes; and in 1882 Mr Howard Saunders was selected to edit the remaining volumes, a task which he successfully accomplished to the entire satisfaction of ornithologists in 1885.

The many excellences of this last edition advanced the work more than ever in the public and in scientific favour. To its stimulating influence is to be mainly attributed the marvellous and unprecedented activity which has resulted in those extraordinary advances made in all branches of British ornithology during recent years—advances which have rendered it essential that a new work based upon this classical and comprehensive foundation should be issued.

During the period alluded to, a considerable number of new and interesting species have been added to our avifauna. The

[Continued on Page 3 of Cover

CONTENTS OF PART XXI.

ADDITIONS TO VOLUME II.

The English local names have been revised in part by Mr W. W. Skeat, M.A. (assisted by the late Professor W. W. Skeat), and in part by Mr C. M. Drennan, M.A. Lond., late Scholar Emm. Coll. Camb.; the Celtic and Gaelic names by Dr E. S. Quiggin, M.A., Ph.D., Fellow and Lecturer in Modern Languages and Celtic of Gonville and Caius College, Cambridge; while a list of Scottish Gaelic names has been supplied by Mr C. H. Alston. Much information has been taken from Mr G. S. Miller's recently published "Catalogue of the Mammals of Western Europe," the use of the MS. and proofs of which before publication was kindly permitted by the Trustees of the British Museum of Natural History.

ILLUSTRATIONS

broad, while in side view it appears to be greatly flattened or compressed.

The female has eight mammæ, arranged in one pectoral, two abdominal, and one inguinal pairs.

Pelage:—The fur is soft and fine, not spiny. It is comparatively short on the face, as well as on the belly, throat, inner surfaces of the limbs, and over the hands and feet. Passing backwards from the forehead, it becomes gradually longer and denser on the back and flanks towards the rump and tail, where it is most luxuriantly developed, and where the woolly underfur is most conspicuous. The hairs also attain a remarkable length upon the outer surfaces of the ears, and especially towards their tips in winter.

There are quite distinct summer and winter coats, but the underside is at all seasons white; the sharp line of demarcation, on each side, runs from the chin to the axilla, where it forms a V upon the inner surface of the fore-limb, and from the posterior edge of the axilla along the lower edge of the flank to the region of the groin and anus.

In complete **summer** coat the colour of the head, body, and limbs is rich rufous, the crown of the head as well as the posterior portion of the back to a variable extent greyer or browner; the tail is creamy, and thinly haired; there are typically no ear-tufts; and the palms and soles are naked. The hairs are not annulated.

In the **winter** the head and body is brownish-grey or greyish rufous brown; the limbs are rufous, but less so than in summer; the tail is blackish or brownish; the ear-tufts long and brown; the palms and soles hairy. The hairs are annulated.

The above description holds good for a typical South English Squirrel, but the moults are very complicated, and the fur is continually undergoing change resulting in much normal variety, so that it might be found impossible to obtain individuals exactly matching the typical description.

The changes are brought about by two annual **moults** of the body-fur and one only of the long hairs of the ear-tufts and the tail. In addition, the tail and ear-tufts undergo gradual bleaching from the deep brown of winter to the cream or straw colour of summer. This is an undoubted change of colour without replacement of the individual hairs.

The *summer* body coat is coarse and short, reaching a length of about 13 mm. over the rump. It makes its first appearance in the south on about the 20th April, and is completely assumed in the course of about six weeks. A Galway specimen had not started assuming the summer pelage on 3rd June 1896. Starting from the muzzle, fingers, and toe-tips, it spreads backwards and bodywards over the face, hands, and feet, to the neck, flanks, and sides, until

it gradually supersedes the old coat, which remains longest on the rump and the backs of the thighs. Notwithstanding this general sequence a patch on the occiput may be latest, and another small patch on the centre of the rump may be the earliest to change. The spring change is remarkable for its "patchy" progress. The summer coat is usually borne until towards the end of October; but a specimen killed at Kilmanock on 20th November 1898 still retained it, the body-fur being thin and reddish, and the tail bleached.

The *winter* body-coat is long and soft, the hairs inconspicuously annulated with brown and dull white, their length about 25 mm. on the rump. It makes its first appearance towards the end of October, and almost immediately starts to bleach, a process continued steadily throughout the winter until the whole animal, with the exception of its rufous limbs, reaches in February or March a uniform dull yellow or drab tint. The spring change to the new coat usually occurs before it can reach the stage of cream colour attained by the tail.

The *tail-hairs* have a cycle running for twelve months from July or August, at which time they make their first appearance as a short blackish covering amongst the roots of their ragged and bleached predecessors. In September, or earlier,[1] they become visible externally, and begin to replace the bleached hairs. Almost immediately after the new growth is completed, they commence to bleach and pass through various shades of brown, pale brown, dull yellowish-brown, until by the following June, July, or August, sometimes even in April, they are almost white. Animals in an intermediate condition present an interesting appearance, in which the tail may be more or less piebald, the middle third of its breadth dusky, with a fringe on each side of ragged, bleached hairs.

Bleaching starts at the tail-tip, which is rarely seen in the full brown condition, and proceeds bodywards. At the same time the hairs gradually wear down or fall out, so that the old tail-coat is thin and poor. The new growth takes place from the body end and reaches the terminal hairs last.

There is no evidence of a regular spring renewal of the tail-hairs. But at least one specimen (mentioned by Thomas), killed on 24th May, shows a growth of new hairs, which, however, may represent a case of very early renewal for autumn, and exactly resembles autumn skins.

The hairs of the *ear-tufts* follow the cycle of those of the tail. They are first noticeable in September, at which time they are dark brown.

[1] One with the tail in a transitional condition was seen at Kilmanock on 21st July 1895, and another with a white tail at the same place on 22nd December 1893. Specimens with dark tails in August are recorded by Butterfield, *Zoologist*, 1896, 348, and G. W. Smith, *ibid.*, 376.

They continue to grow until January, at which time they have attained a length of about 35 mm. They afterwards become white and thin, and, if they persist after July, are rendered conspicuous by their light colour.

The *palms and soles* are naked from April to November, but during the latter month acquire a coat of short woolly hairs, thicker on the soles than on the palms, which are sometimes more or less unclothed even in winter.

The remarkable cycle of moult and colour-changes indicated above, although considered by Thomas, who first described them in detail (*Zoologist*, 1896, 401), as "both in effect and complexity, quite unparalleled throughout the mammals of the world," had previously been neglected or misunderstood. Blyth[1] probably came nearer to an understanding of them than any other writer, and Macgillivray and Alston (*in Bell*) had a rough notion of a regular sequence, but the majority of naturalists were content to regard the cream or whitish tail as an "accidental variety." Thomas's work was based on the study of a series of Squirrels killed all the year round in a single wood at Whatcombe, near Blandford, Dorsetshire, by Mansell-Pleydell; and although typical enough for British Squirrels generally, Thomas's calendar of the changes must not be regarded as absolutely binding for those taken in other parts of the country. A series procured for Barrett-Hamilton at Saffron Walden, Essex, exhibits a greyer coloration in winter.

Blyth (*loc. cit.*) states that in the case of the young of the first litters the first pelage is that of winter, and this is corroborated by A. H. Macpherson (*Zoologist*, 1886, 67), who twice found young in the nest with bleached tails and ear-tufts, and by Aplin (*Zoologist*, 1885, 479). According to Blyth, the pelage of young of the second litter is that of summer, ear-tufts being absent.

The immature are often redder than are adults. The tails, never rufous in adult *S. leucourus*, are frequently so in young specimens, which thus resemble adult *S. vulgaris* rather than their own parents—a circumstance which, as Thomas remarks, "would tend to show that . . . the British Squirrels were formerly red-tailed when adult."

Eagle Clarke, writing of three males and three females sent from Ballindalloch, Spey, Scotland, on the 3rd March, states that the males were greyer, the females slightly more rufous, especially on the flanks; but there is yet no evidence available indicating that this is the case generally in *S. leucourus*, although Gray (*Ann. Mag. Nat. Hist.*, November 1867, 325) states that this is true of certain South African Squirrels.

Collett (*Norges Pattedyr*, 1911, 217) has proved (from the examination of a long series collected in southern, central, and northern

[1] Ed. White's *Selborne*, London, 1836, 280, 281, note.

Norway) that the Norwegian Squirrels (now referred to *S. v. vulgaris* and *v. varius*) have similar moults to those observed in *leucourus*. Thus the body-fur is shed and renewed twice a year—in spring and in autumn; the ear-tufts and tail-hairs only once—in the course of the summer. Though subject to considerable individual variation, the precise moment of change, as in England, appears to depend very little upon weather. At the autumn moult, the first grey hairs appear on the posterior half of the back; then they appear on the upper surface of the thighs and forepart of the back; later they spread over the flanks and fore-limbs; and lastly on the belly and inner sides of the thighs. The spring moult follows a converse order: the belly first becomes thin haired; then the outer sides of the arms become red; next the flanks and inner surfaces of the thighs become yellowish-red; after this the grey hairs fall from the outer sides of the thighs, and lastly from the back, where in the neighbourhood of the rump long pendulous grey hairs can remain until a very advanced date. The colour-changes of the Norwegian animals are produced solely by the replacement of the old hairs by a new growth, and the bleaching process, so characteristic of the British species, is apparently quite unrepresented in them, as well as in the other continental races of *S. vulgaris*.

Bleaching is known to occur also in *Heliosciurus mutabilis*, a species inhabiting Nyasaland (Thomas, *P.Z.S.*, 1894, 140), and in *Ratufa bicolor*, a Giant Squirrel inhabiting Java (Bonhote, *A.M.N.H.*, [7] v. 490). In *leucourus*, as pointed out by Thomas, it "takes place mainly in the winter and early spring, so that it cannot be assigned to the special action of the summer sun." Further, it affects only the annulated hairs with blackish-brown pigments, and not the unannulated hairs with rufous pigment; thus in "February and March skins, the whole animal, from nose to tip of tail (but not the rufous limbs), is bleached to one uniform dull yellowish or drab tint" (Thomas, *Zoologist*, 1896, 406). It seems probable from these facts that there is an important difference in the chemical constitution of the red as opposed to the blackish-brown pigment; the bleaching of the latter appears to be a process strictly comparable with that which we have described as taking place in the hairs of the House Mouse (*antea*, p. 643).

It is of interest to note in conclusion that Collett (*op. cit.*, 220) has described two distinct pelages of the young Norwegian Squirrels. According to him, nestlings first develop a red coat in which there is usually a more or less strong intermixture of whitish-grey hair, especially noticeable on the head and flanks. In this pelage, especially in Northern Norway (Finmarken), the grey tone may be as strongly evident as in the winter coat of many adults. This "nestling" pelage is changed apparently wholly or in part when the young are half grown, and it is succeeded by the true juvenal pelage, which is quite red. The

a b

THE BRITISH SQUIRREL—*Sciurus leucourus.*

TAIL (half life size), showing normal flattening—(*a*) dorsal view; (*b*) lateral view.

latter is borne until the autumn, when it is changed for the normal first adult winter pelage, the moment of change, however, being frequently later than in adults. The nestling pelage of Collett may perhaps be compared with that described by Blyth and others, noticed above, but it is to be hoped that some favourably situated observer will give further information concerning the first pelage of *S. leucourus;* at present we have little material bearing upon this matter.[1]

Variation:—Thomas's Dorset series may be regarded as typical. Squirrels from colder parts of the country are greyer in winter, with a darker, browner central dorsal line, and in summer redder flanks. An extreme example of this type was taken near Bury St Edmunds, Suffolk, in very cold weather on the 2nd February.

S. leucourus, being confined to Britain, has no definite **geographical variation**, such as is exhibited in a very beautiful manner by its closely allied representative, *S. vulgaris*, on the continent of Europe.

Exceptional variation runs mainly towards albinism; melanism, although extremely common in some of the sub-species of *S. vulgaris*, being almost unknown. Of the latter variation, records of only three instances, and no detailed descriptions, are available (see Pryor, *Zoologist*, 1865, 9431; Denham, *Field*, 24th April 1909, 721). Records of albinos will be found as follows:—(1) male, pink-eyed, Dack, *Field*, 5th December 1885, 785; (2) large white saddle on back, feet, nose, and three parts of tail white, pink-eyed, Dack, *Field*, 3rd November 1888, 653; (3) Laws, *Field*, 14th December 1889, 862; (4) female, pink-eyed, Matthews, *Zoologist*, 1892, 20; (5) Rushen, *Field*, 24th June 1893, 944; (6) male, pink-eyed, Marsden, *Zoologist*, 1893, 426; (7) female, pink-eyed, *Auct. et Journ. cit.*, 457; (8) pink-eyed, Grabham, *Zoologist*, 1899, 132; (9) pink-eyed, Monckton, *Field*, 28th January 1905, 152; (10) one, white (figured), Brown, *Field*, 8th January 1910, 74.[2] A white Squirrel was killed near

[1] W. Evans (Supplement, *Proc. Roy. Phys. Soc. Edinburgh*, 16, 1906, 398, and *in lit.* to Barrett-Hamilton) has described young, three to ten days old, from two nests in the Edinburgh district. In one case, examined 21st April 1904, the three still blind nestlings "seemed to be rather less than 3½ inches in length, exclusive of tail, which might be fully 2½ inches, and showed no tendency to curl upwards over the back. They were covered on the upper surface with very short silky hair of a rich chestnut or rufous colour; skin on upper parts of legs and about the eyes bluish; under surface yellowish-white; tail straight and clothed with short blackish hairs." The other nest, found 4th May 1904, contained "three young ones, naked and blind and not more than three or four days old." Evans figures one of these babies, which he sent to Barrett-Hamilton; he says: "Its length was 75 mm. excluding the tail, which measured 40 mm.; colour, dark bluish-grey."

[2] Cocks put "three young squirrels to a domestic cat, and eventually sent them to the Zoo, where one soon died, but the other two were reared. These turned *white*, but whether because they were albinos, or in consequence of the influence of the cat's milk, or the absence of sunlight from the keeper's room in the small mammal house at the Zoo, cannot be said."

Gorebridge, Midlothian, in January 1908 (W. Evans, *MS.*). Of parti-coloured specimens the following are remarkable: one, having the moustache, nose, upper lips, forefeet, two joints of the hind toes, and the claws white, with, in addition, on each side a band of white, an inch broad, proceeding from the white of the belly, and nearly meeting its fellow dorsally; a similar band, about 2 inches broad, towards the tip of the tail was arched over the back (Bold, *Zoologist*, 1848, 195). The latter seems to have been somewhat similar to one in the collection of J. W. Whitaker, of which he kindly sent us a sketch; this specimen was shot in Nottinghamshire, and has a broad transverse band of white, only narrowly interrupted dorsally, around the middle of the body, the nose, fore-limbs, and distal half of the tail being also white. A third specimen of somewhat similar appearance was noticed in the *Field* of 3rd November 1888, 653 (C. B. Dack).

Skull:—The **skull** is broad, smooth, and rounded, with a short, narrow, but deep rostrum, and a large, broadly ovate and deep brain-case. In dorsal profile the nasals are slightly, and the fronto-parietal region very, boldly convex; the line is slightly concave between the orbits, and again just in front of the occiput; these concavities mark the positions of the internal divisions between the cerebral part of the brain-case and the olfactory and cerebellar fossæ respectively. The occiput is vertical or slightly overhanging, the condyles being hidden in the dorsal view, and owing to the backward deflection of the cranial axis the foramen magnum lies wholly below the level of the alveolar line. The nasals are short and broad, widest and well arched in front; their tips end well in advance of the incisors; posteriorly their ends lie a little in front of the very broad ends of the ascending branches of the premaxillæ. The frontals have large superciliary processes, which partly roof the orbit and terminate behind in long, slender, postorbital processes, directed backwards, outwards, and downwards. From the hinder edge of each of these processes a feebly indicated temporal line passes backwards to blend with the weak lambdoid crest; the fronto-parietal area between the two temporal lines is lyre-shaped. The inter-parietal is small and distinct in young skulls, but in adults it is completely fused with the parietals. The very small infraorbital foramen on each side is placed considerably in front of the cheek-teeth, and its lower edge forms a conspicuous little process of the maxilla for the attachment of the tendon of the masseter. The anterior root of each zygomatic arch is a stout plate, homologous with the "masseteric plate" of the murine skull; the ridge which forms its upper boundary and marks the limits of the origin of the *masseter lateralis* muscle is continued forwards for some considerable distance upon the side of the premaxilla. The large jugals form distinct though low postorbital crests; posteriorly they articulate by means of a long scale-like suture

with the squamosals, anteriorly with the zygomatic plates of the maxillæ and with the small lachrymals. The greatest zygomatic breadth falls slightly in front of the glenoid regions. The anterior palatal foramina are very short and narrow; they barely notch the maxillæ. The palate is broad and flat, or rather slightly concave, with a more or less evident trace of the median suture; the maxillo-palatine suture extends forwards to the level of m^2; the posterior palatine foramina are very small; the palatines extend for 2 or 3 mm. behind m^3, each having a well-marked circular notch on its margin behind that tooth. The meso-pterygoid fossa is wide, and squarely truncated in front; the pterygoid bones are small and thin, their hamular processes considerably in front of the bullæ; the ecto-pterygoid processes are feeble ridges, and behind each is a very large *foramen ovale.* The presphenoid and basi-sphenoid are wide and little modified. The ventral surface of the broad basi-occipital has the median ridge and lateral concavities little developed, but its margins are raised as conspicuous little flanges which are applied to the inner surfaces of the bullæ. The paroccipital processes are small, short, and stout, terminating above the level of the condyles. The bullæ are small, round, and moderately inflated; internally they are divided by a number of bony septa; the external meatus of each shows the beginning of a funnel-shaped prolongation; the petrous portions are of moderate size.

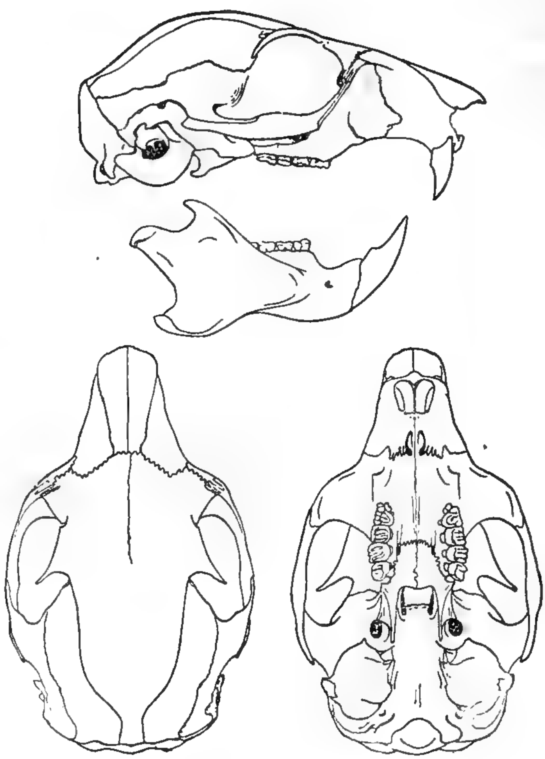

FIG. 99.—SKULL OF SQUIRREL (*Sciurus vulgaris*). Life size.

The **mandible** is laterally compressed, and in relation to the molars deep and heavily built. The lower incisors pass upwards close behind m_3 to terminate in the bases of the coronoid processes. The condylar

and angular processes are stout; the coronoid processes are rather slender and recurved, but they rise noticeably above the level of the condyle.

The **dentition** has been described above under the genus, p. 686.

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without hairs).	Hind foot (without claws).	Ear (without tufts)	Weight in grammes.		Head and body.	Tail (without hairs).	Hind foot (without claws).	Ear (without tufts).	Weight in grammes.
SCIURUS LEUCOURUS.											
1. SPECIMENS FROM WHATCOMBE, BLANDFORD, DORSET (B. M. serial, No. 97, 1-16).											
MALES:—						FEMALES:—					
1. 21st Jan. 1895	205	185	55	30	..	1. 21st Jan. 1895	216	162	59	28	..
2. ,, ,, .	222	169	56	27	..	2. 18th April .	213	166	55	27	..
3. 9th May .	211	169	59	27	.	3. 2nd May .	207	187	59	29	..
4. ,, ,, .	209	178	56	29	..	4. ,, ,, .	192	172	55	28	..
5. 24th ,,	200	139	56	29	..	5. 24th ,, .	219	176	56	35	..
6. 15th Aug. .	202	176	56	28	..	6. 13th Sept. 1894	216	170	59	29	..
7. 17th ,, .	196	155	53	27	..	7. 30th ,, 1895	213	170	55	28	..
8. 19th ,, .	202	184	58	28	..	8. ,, ,, .	193	158	55	18	..
9. 30th ,, .	205	165	56	28	..	9. 24th Oct. .	210	175	55	27	..
10. 13th Sept. .	196	160	52	27	..	10. 29th ,, .	216	172	58	29	..
11. 9th Oct. .	195	149	55	27	..	11. ,, ,, .	202	185	57	29	..
12. 15th Dec. 1894	216	182	57	28	..	12. 6th Nov. 1894.	215	171	55	28	..
Average of 16 males in adult pelage (including the above) .	205	169	55	28	..	Average of 35 females in adult pelage (including the above) .	207	172	56	28	..
2. SPECIMENS FROM SAFFRON WALDEN, ESSEX.											
13. 25th Sept. 1896	201	174	54	..	..	13. 1st Oct. 1895 .	198	166	55	..	..
14. 2nd Nov. 1895	218	170	62	..	..	14. 30th Sept. 1894	218	170	53	..	227
15. 26th Oct. .	220	174	58	..	..	15. 30th Mar. 1895	220	172	54	..	..
16. 2nd Nov. .	220	163	59	..	..	16. ,, ,, .	228	177	55	..	..
17. 29th Aug. 1896	225	164	55	..	..	17. 4th July 1894 .	232	166	57	..	..
18. 27th Feb. 1895	238	188	58	..	..	18. 15th Dec. 1894	234	172	57	..	..
19. 27th Ap. 1894.	243	168	56	..	340	19. 20th June .	238	175	57	..	..
Average of 21 males in adult pelage (including the above) .	220	170	56	..	..	Average of 21 females in adult pelage (including the above) .	217	171	54	..	..
3. SPECIMENS FROM SCOTLAND.											
1. Ballindalloch, Spey, 3rd March 1892 (W. Eagle Clarke), male . .							237	170	63	35	334
2. ,, ,, ,, ,, . .							229	165	59	33	278
3. ,, ,, ,, ,, . .							..	..	.	..	336
4. ,, ,, ,, female . .							213	162	56	31	330
5. ,, ,, ,, ,, . .							221	167	61	33	340
6. ,, ,, ,, ,, . .							213	178	58	31	253
7. Nethybridge, Inverness-shire, 14th-17th March 1913 (C. H. B. Grant and D. Anderson), male							210	170	56	31	..
8. ,, ,, ,, ,, ,, female							205	171	55	30	..
9. ,, ,, ,, ,, ,, ,,							208	181	57	29	..
10. ,, ,, ,, ,, ,, ,,							218	171	55	30	..
11. ,, ,, ,, ,, ,, ,,							219	176	56	27	..
12. Blackwood, Lanarkshire, 24th Sept. 1904 (N. B. Kinnear), female .							208	168	55	29	312

Remarks:—All the specimens dealt with in the foregoing tables were in adult pelage; the individuals enumerated include the largest and the smallest specimens of each sex in each of the long series examined from Blandford and Saffron Walden. Macgillivray states that the female is smaller than the male; to some extent this statement is supported by the above figures, although the difference is small; the largest males appear to exceed by 5 mm. the largest females as regards the length of the head and body.

Weight:—Four from Saffron Walden were weighed, viz., a male and a female (Nos. 19 and 14 respectively of the above table) of 12 and 8 oz., or 340 and 227 grammes respectively; and two males, one taken on 26th April (head and body, 235) of 10 oz. or 283 grammes, the other killed on 30th September (head and body, 227) of 9 oz. or 255 grammes. A male from Upware, Cambridgeshire, taken on 24th August (head and body, 224) weighed 8¾ oz. or 248 grammes. Three males, killed 26/27 December, from Co. Wexford (lengths unrecorded), weighed 10, 10½, and 11¼ oz., or 283, 298, and 319 grammes respectively. The heaviest, of which we have a record, was a male from Ringwood, which reached 17 oz. or 482 grammes (Corbin, *Zoologist*, 1886, 178).

Skull:—Condylo-basal length, 44 to 48: breadths—zygomatic, 29 to 31·6; mastoid, 21 to 22·2; least postorbital, 17 to 18·2; least interorbital, 16 to 18; anterior rostral, 7 to 8·8: lengths—of nasals, 13·8 to 15·8; of diastema, 11 to 13; of maxillary tooth-row, 8·8 to 9·6; of mandible, 30 to 33·6; of mandibular tooth-row, 8·4 to 9·4.

The form and habits of this elegant little creature combine to render it one of the most beautiful and entertaining of our native mammals. Dwelling principally upon trees, but frequently descending to the ground, it leaps from bough to bough with astonishing agility; but should it miss its mark it usually alights safely like a cat, and runs away little the worse for a fall from even a considerable height.[1]

Though bold and easily observed, it is subject to fits of panic, and exhibits a somewhat contradictory character. Thus, although not hesitating to descend to the ground and roam for a considerable distance from trees, it will, on the slightest alarm, race in a series of long bounds for its leafy refuge. With the utmost circumspection it carefully climbs the tree-trunk, on the side away from its enemy; but then, perhaps thinking itself secure and possibly overcome with indignation

[1] See Editor, *Field*, 24th September 1893, 473; on the other hand, W. H. Scott, *ibid.*, 1900 (95), 771, records the death of one from a fall.

or curiosity, it usually emerges into full view, often within easy gunshot, and, neglecting to make good its escape, sits chattering, swearing, and stamping its feet, a charming picture of fuss and impudence. On such occasions, as Sir H. Johnston observes, its voice is capable of considerable variation, ranging from a series of metallic "clacks" to a rapid succession of spitting squeaks.

Much of the Squirrel's characteristic appearance is due to its tail, an appendage with a great variety of uses and playing the chief part in almost every incident in its owner's career. In climbing, running, swimming, or leaping, the tail is directed straight backwards, serving as a balancer, rudder, or combined with the horizontally spread limbs and the distended loose integument of the flanks as a parachute. In sleep it covers and warms the whole lateral and dorsal portions of the body. When the animal is more or less quiescent the tail is bent abruptly forwards along the back towards the head, the tip slightly recurved outwards. At such times the various emotions are expressed apparently by a series of jerks of the tail, which may perform the part of a banner of defiance, or a lure to a genuine or sportive adversary. To enable it to play its varied roles, the tail possesses extraordinary mobility, and is provided with special muscles whereby the arrangement of the hairs may be suited to fit each passing mood. The hairs may at will be horizontally flattened for purposes of balance, or each hair may stick out directly from the central support, so that the outline of the tail is circular like the plume of a hussar's busby. The latter shape is affected especially when another Squirrel is the subject of sport or defiance; the hairy tail is literally thrust into the mouth of the adversary, and is used as an invulnerable hairy vanguard to excite and confuse the enemy.

The Squirrel has little fear of the proximity of man; it often enters the pleasure-grounds of large towns, and indeed frequently courts the vicinity of houses, being, doubtless, attracted by the produce of their gardens; of diurnal habits, it is frequently visible, in such circumstances, from the windows of houses surrounded by woods. If fed and encouraged—and nothing, from bread to a chicken-bone, comes amiss to it—it

sometimes becomes very familiar, and soon learns to enter by the windows to secure an accustomed meal. Even perfectly wild Squirrels have been known to climb or enter a house, either to escape danger, to rob a sparrow's nest of the young birds, or even, in hard weather, to steal bread.

Its food is very varied, and includes almost every vegetable substance from which nourishment can be extracted. In text-books the nuts of the hazel usually appear first in its dietary; but, if the truth be told, they are probably eaten much more rarely than are many other more easily obtainable substances, such as leaf-buds and tender shoots, young bark, acorns, beech-mast, seeds of sycamore, fir-cones and haws, all of which are included in every comprehensive list. It also feeds largely on fungi (agarics, etc.) in the autumn (W. Evans). Mr O. V. Aplin[1] has described the actions of a pair of Squirrels as they gathered beech-mast and carried it away to their winter retreat in some thick firs. He says:—"As the mast grows at the extreme outside of the trees, and only at the end of the slender drooping twigs, and usually out of (Squirrel) reach of any of the thicker branches, I imagined they had to content themselves with any of the fallen nuts. But I found that they ventured boldly out into the small twigs, and, hanging on by their hind legs, drew the mast to them by their forepaws and bit it off, when, with the exercise of the greatest agility, they twisted round, and with a quick jump regained the stronger branches. Of course, a good deal of the mast fell to the ground, and Squirrels seemed occasionally to get quite out of temper with a refractory twig which refused to come to hand; when this happened, the angry impatient snatches made by the little animals were quite amusing. No doubt they felt their position precarious, for the breaking of a twig or the slip of a claw meant a clear twenty-foot drop, with nothing to catch at: no great matter, of course, to a Squirrel when it throws itself off a bough to drop, parachute-like, to the ground, but quite another thing when taken as an unexpected fall."

Whenever opportunity offers, it leaves the woods in search of fruit, pilfering plums, Spanish chestnuts, cherries, apricots, peaches, strawberries, pears, and bilberries. As a rule it eats

[1] *Zoologist*, 1885, 478.

only the soft parts, but sometimes the kernels are devoured. There can be no doubt that, when numerous, apart from its depredations in gardens, it often causes serious damage to plantations; and, although the lover of nature may agree with Sir H. Johnston, that its misdeeds are partially atoned for by its fascinating appearance, the prudent forester will keep its numbers from assuming inconvenient proportions. One of the most conspicuous of its misdemeanours is its habit of attacking the early leaf-shoots of the horse chestnut, or less frequently of sycamores, which in spring appear to be very palatable to it, and are ruthlessly torn from the tree and then thrown to the ground. It is no less destructive to the young shoots and leaves of the beech. Alston accused it of barking young birches,[1] and a number of authorities have shown that amongst its gravest offences is the stripping off of whole areas of bark right round a tree trunk, especially a conifer, at a distance of a few feet of the top—thus damaging the leading shoots. This it does to get at the inner bark. The resulting damage is incurable in the case of conifers, the tops of which decay and then turn over before the wind. Such crimes chiefly occur in the new woods of replanted areas, and are most often seen in trees of about twenty years' growth. Younger trees appear to be exempt, as do also the older firs of native forests, in which the more abundant cones supply a quantity of food.

The loss from such attacks has been estimated at very high figures in Scotch forests. At Glen Tanar, Aberdeenshire, one thousand trees worth £500 were ruined in one year; and on the Cawdor Estates it was considered worth while to pay over £200 for the destruction of more than fourteen thousand Squirrels between the years 1862 and 1878.

But there is another count on which the Squirrel must meet with our righteous condemnation, namely, for its destruction of the eggs and young of birds, concerning which the testimony of many accusers is, despite a vigorous defence by the many admirers of the culprit, now unquestionable. Thus Captain Saville G. Reid charges it with robbing the nests of the Long-eared Owl, and, on one occasion, of the Greater Spotted

[1] Cocks finds young crabs (while still in more or less bush form, before they become single stemmed trees), barked throughout at Poynetts.

Woodpecker. The Rev. A. Ellison finds that in Ireland it is one of the worst enemies of small birds, of which it devours both eggs and young. Indeed, once the bird-nesting habit has been acquired—for it must be admitted that it does not manifest itself universally in the species—eggs, fledgelings, or, if they can be surprised, even adult birds are all acceptable;[1] and one has even been discovered in the act of carrying off a small chicken from a poultry yard. It is a clumsy robber, and its handiwork may be recognised by the portions of its repast left behind or scattered about the raided nest. Captain Reid protected a Woodpecker's nest from further disturbance by smearing a ring of tar around the trunk.

The Squirrel is not content to restrict itself to such provender as is provided by woods. All through the year it may be seen, either in search of food or of nesting materials, grubbing assiduously on the ground, often at a little distance from trees. At such times it is very active, working hard and spending much time at its exercise. From time to time it desists from its exertions either to survey its surroundings or to drive away a comrade—the pursuit being often hot enough to include much doubling and winding, and perhaps a chase up a tree. Frequently also it sits bolt upright, the tail lying at right angles along the ground evidently as a support, and, holding some dainty in its paws, nibbles and eats; but if the object of its attentions be of comparatively large, although portable size, it usually retires with its booty up a tree, as when Mr W. Evans found one carrying a mutton bone fully 7 inches long. Its gait is not a walk or a run, but a series of short leaps, the fore and hind limbs working together in pairs. On its terrestrial expeditions it has been found to devour plantains, daffodils, crocuses (the whole plant), tubers of the lesser celandine, Indian corn and ants' eggs. It

Fig. 100.—Spoor of Squirrel in Snow.

[1] Cocks says (*in lit.*):—"There are some spruce firs near the house here [Poynetts], always utilised by sparrows for nesting, 25 to 30 feet up, but for several years now not a single young bird has flown, all the nests being regularly raided by squirrels. They destroyed a nest-box in a Scotch Fir adjoining these. If they thus take *every* sparrow from this particular *scattered* lot of spruces they must do serious damage to other small birds of more value."

is also fond of several kinds of fungi, including mushrooms, and will tear off old bark of trees in search of them. Von Tschudi long ago declared that the Alpine Squirrels dig up truffles, and this observation was repeated for Britain at Elveden, Suffolk, by the late Prof. A. Newton and one of his brothers, and in Ireland by Mr P. Bicknell.

In eating, the Squirrel holds its food to its mouth with its fore-paws. In gnawing through the hard shells of nuts it displays much skill. Captives observed by Mr Bonhote always held a nut by the larger end and nibbled a hole into the smaller end; when the hole was large enough, they inserted their lower incisors, and with a sharp jerk of the head a piece of the shell was broken off, an action repeated until the kernel could be extracted. The scales of fir-cones are bitten off, and the seeds devoured; the presence of fossil fir-cones in the late pliocene Forest Bed of Norfolk gnawed in this way has been mentioned above (p. 695).

Sometimes the terrestrial foraging expeditions are carried far afield, as must needs be the case when it journeys from one wood or plantation to another, and Barrett-Hamilton knew one to be caught in a trap set for rats in a field of cabbage. It has been frequently encountered amongst the heather of the Scotch moors, and a number of instances of such wanderings were collected by Mr Harvie-Brown while compiling his paper on the Squirrel in Great Britain. From these it appears that single Squirrels have strayed for distances of at least 9 miles from the nearest trees, so that it is not surprising to find that newly wooded districts are rarely long neglected by this species, as has so frequently been shown in Scotland, Wales, and Ireland. Sometimes wandering Squirrels find themselves in very unexpected quarters, as after entering houses by their chimneys. The most remarkable escapade is that related by Mr A. E. Knox of a Highlander, who, never having seen a Squirrel before, came across one on an open moor. It is doubtful whether man or Squirrel was the more surprised: the latter, to avoid the Highlander's dog, promptly climbed to the top of the man's head; the Highlander, greatly alarmed, believed his assailant to be "a thing wi' horns." It appears that roads, walls, rails, or hedgerows, and even railway bridges

have much influence upon the wanderings of the Squirrel since it loves to follow anything straight.

Even when it meets water it is not always nonplussed, for, although the larger Scotch rivers, until bridged, are said to have proved effectual barriers to its repopulation of that country, it has undoubtedly the ability to cross wide streams. The Squirrel has been figured while swimming by Mr Millais. It swims high, the tail flat on the water. Amongst the most conspicuous instances of its activity in this direction may be counted the discovery of one crossing Loch Toil where its breadth reaches one-third of a mile, by a lady correspondent of Colonel H. H. Godwin-Austin; while another was seen to cross the River Spey, where the stream is broad, strong, and deep; and Mr Meade-Waldo saw one swim across Loch Ericht at a place where the loch was one mile wide—when this Squirrel landed its tail was perfectly dry.

The Squirrel has been credited by most writers with provident sagacity in laying up stores of food for the proverbial rainy day. "I have a venturous fairy," says Titania, "that shall seek the Squirrel's hoards and fetch thee new nuts." The distribution of these reserves, not in a single place of safety, but in several holes in different trees in the neighbourhood of its retreat, has been often regarded as further evidence of forethought; but, if the truth be told, the Squirrel is but a careless housekeeper at any time, and no more worthy of praise in this respect than the well-fed dog which spends its spare time in burying the bones which it is unable to consume. The erratic nature of the Squirrel's stores was long ago commented upon by Alston, who watched the storing operations of a semi-tame individual. This Squirrel, when fed with nuts out of doors, hid them in a most capricious manner in soft turf, not taking them all to one place, but burying them anywhere at random, so that "one could hardly believe he would ever find them again; and I have no doubt that he never did find some of them."

The habit of storing surplus food, be it intentional or the result of blind energy, is present, as in so many other rodents; and there can be no doubt that, although of comparatively little importance in this country, in severer climates than that of Britain it must be a necessary action, failure to perform which

may result in the death of the defaulter. In North America Dr Merriam states that the Red Squirrel (*S. hudsonicus*) makes larger stores and fares better in winter than the Grey Squirrel (*S. carolinensis*).

It seems more than probable that many of the older myths which gathered around the Squirrel's "treasured hoards" owed their prevalence to the still more erroneous belief that the animal remains during the greater part of the winter in a state of almost complete torpidity, from which it only relapses on fine days for the purpose of feeding. As a matter of fact, the Squirrel is quite active throughout the winter and in all degrees of cold. This fact is none the less compatible with a strong dislike of snow or rain, during the prevalence of either of which it may remain in its nest for several days together. Notwithstanding any such prejudices, however, it is often to be observed abroad in all kinds of weather, and Mr Hewitson remarks that its footsteps are the first to soil the unsullied beauty of the snow. He records an extreme case in which young Squirrels, little more than able to leave the nest, were running about on snow in March.

Some of the most interesting or striking myths deserve mention. Pennant and Bingley relate of it that its gullet is very narrow, "to prevent it from disgorging its food, in descending of trees, or in down-leaps." Topsell, repeating an ancient and widespread legend, the details of which, according to Mr Harvie-Brown, are still related as actual facts of natural history in Scotland, says:—"If they (*i.e.* Squirrels) be driven to the ground from the trees to creep into hedges, it is a token of their weariness, for such is the stately mind of this little beast, that while her limbs and strength lasteth, she tarryeth and saveth herself in the tops of tall trees, then being descended, she falleth into the mouth of every cur. The admirable wit of this beast appeareth in her swimming or passing over the waters, for when hunger or some convenient prey of meat constraineth her to pass over a river, she seeketh out some rinde or small bark of a tree, which she setteth upon the water, and then goeth into it, and holding up her tail like a sail, letteth the wind drive her to the other side; and this is witnessed by Olau Magnus in his description of Scandinavia,

where this is ordinary among squirrels by reason of many rivers, that otherwise they cannot pass over, also they carry meat in their mouth to prevent famine whatsoever befal them, and as peacockes cover themselves with their tails in hot summer, from the rage of the sun as under a shadow, with the same disposition doth the squirrel cover her body against heat and cold."

Mr E. H. Cuming quotes the old writer, Lovell, that the tail "serveth them as a wing in leaping. They obscure themselves with it in trees and use it as a sail in the water, swimming upon a bark." In Skandinavia, according to Alston, it bears the character of a tale-bearer, for ever and anon it runs up and down the sacred ash tree, *Ygdrasil*, which supports the world, spreading discord between the eagle seated on the boughs and the great snake, *Midgårdsörmen*, which lies in the abyss beneath. It is not unlikely that this belief may have something to do with the practice of the German peasants who hunt it at Easter, and of the English who hunted it at Christmas. Simroth attributes these practices to "Christian hatred of the darlings of the heathen gods." Apparently the chase did not always result in harm to the Squirrels, since Mr Briggs writes of Duffield, Derbyshire, where Squirrel hunts were customary on Mondays, that after the capture of several they were taken back to the village, released, and the hunt renewed. The plan of campaign was to make such an uproar with the blowing of horns and other instruments that the frightened creatures eventually dropped off the trees and were taken. But the Squirrel is not always so resourceless, a hunted one having been observed, there being no tree available, to take refuge in a heap of stones. Mr W. Evans has, on several occasions, seen it going to ground in a rabbit burrow when hotly pursued, and it has even been dug out like a fox.

Organised hunts could hardly have been common until after the destruction of the forests in the Middle Ages, when the woods had become thinner, and the old rhyme prevalent in one form or another in many localities was no longer true—

> "From Blacon Point to Hilbree
> A Squirrel may jump from tree to tree."

The Squirrel loves comfort, and prepares for its sleeping-place a capacious nest or "drey" built high amongst the branches of a tree—in Scotland very often a fir of some kind, according to Mr W. Evans—or hidden inside a hollow trunk.[1] This is constructed in a very beautiful and intricate manner of moss, leaves, and fibres curiously interleaved. It is lined with dry grass or wool[2] if available, and looks like an immense wren's nest. Usually a definite entrance is wanting, the sides being elastic and self-closing after the inmate has passed through. At all times, even if present, the orifice is hard to find—a fact which probably induced Pliny's remark that the owner closes its retreat on the side from which the wind is likely to blow and opens it on the opposite direction.[3]

The Squirrel is sometimes a sound sleeper, and may, on occasion, be caught napping. Since its presence inside the drey cannot be detected until the touch of the birdnester's hand arouses it, its sudden exit is often not a little disconcerting

[1] Probably climate and season have something to do with the site of the nest. In the cold regions of North America, Squirrel nests are invariably concealed in holes in trees, or even in the ground, while in the more temperate regions they are built in branches of trees, like the nests of crows (Merriam, *Mamm. Adirondacks*, *Trans. Linn. Soc. New York*, ii., 1884, 132).

[2] Squirrels were seen by Hodgson collecting sheep's wool for this purpose from a thorn hedge (*Trans. Cumberland and Westmorland Assoc.*, 1885-86, 30). Mr W. Evans (*in lit.*, 23rd March 1910) has given us detailed information as to the structure of three breeding nests examined by him. One (at Clubbiedean, Pentlands, 23rd March 1896) was "profusely lined with sheep's wool, etc., but no young in it yet." Another (near Edinburgh, 21st April 1904, with three young) had a "foundation of twigs, then moss outwardly, and lined with profusion of sheep's wool and rabbits' fur; green leafy fir twigs were placed on top of nest." The third (near Edinburgh, 4th May 1904, with three small blind young) was "made outwardly of moss, then shreds of inner bark of lime, followed by a dense matted lining of rabbits' fur, mixed with bits of fibre and some feathers of pheasant and wood-pigeon; thatched with fresh spruce twigs; approximate diameters: horizontal, 10 inches; vertical, 13 inches; circumference about 35 inches." Mr Moffatt saw one "freshly lined with squirrel's fur and covered with fresh moss"; and Mr C. E. Wright of Kettering found a nest in a hole in a tree "lined with a little fur on leaves."

[3] The ancients held a similar belief regarding the hedgehog: this is mentioned by Aristotle (*Hist. Anim.*, D'A. W. Thompson's ed., 1910, ix., 6, 612 b, 4), Plutarch (*Soll. Anim.*, 979 A), and in Pliny (viii., 56): "In regard to the instinct of hedgehogs, it has been observed in many places that, when the wind is shifting from north to south, and from south to north, they shift the outlook of their earth-holes, and those that are kept in domestication shift over from one wall to the other (Plutarch). The story is that a man in Byzantium got into high repute for foretelling a change of weather, all owing to his having noticed this habit of the hedgehog."

to a climber balanced at some considerable altitude in a precarious position.

Occasionally Squirrel's nests are reported from curious situations, as when the Rev. J. G. Tuck found one in a loophole of the church tower of Tostock, Suffolk. Its foundation was an old sparrow's nest, to which a quantity of dry grass had been added. A second remarkable nest, of which Mr Forrest sent Barrett-Hamilton an account, was placed in a straggling gorse bush at a height of not more than 4 feet from the ground. Sometimes an old magpie's nest may be put into repair by the Squirrel, which probably has to renovate its drey every season, although the dreys are built of a strength sufficient to last for years. An impossible situation sometimes ascribed is a woodpecker's hole in a tree trunk, but clearly such a hole would be too small to admit the body of a Squirrel.

Mr W. Evans says: "Clean and trim as it appears to be, the Squirrel, like the Hedgehog and the Mole, is greatly infested by a flea, the species in this instance being *Ceratophyllus sciurorum*, Bouché, which is invariably present, and usually in abundance, both in the nests and on the animals themselves."[1]

Every Squirrel is supposed to possess two or three dreys, and one of these is no doubt strengthened and repaired for the reception of the young. According to Edward Jesse,[2] the prospective mother begins by gathering mouthfuls of dry benty grass, of which she makes a considerable deposit. Just before the young are born, she scratches or pulls the fur off her stomach, and thus makes them a warm lining.

The number of young varies from one to six,[3] and the average of twenty litters, recorded in Barrett-Hamilton's notes, from many parts of the British Islands is three. Two litters each summer would appear to be quite usual in the south (though not in Scotland), but the young are most often found in the nests in March and April. Earlier instances are, how-

[1] W. Evans, Supplement, *Proc. Roy. Phys. Soc. Edinburgh*, 1906, 400.

[2] *Gleanings of Nat. Hist.*, 1842, 214.

[3] One litter of six from Ashburnham Park, Sussex, 15th April 1895, *fide* N. F. Ticehurst. Mr Oldham (*in lit.*) mentions a drey with five young, observed by him near Droitwich on 31st August 1918; above the drey three young, belonging to an earlier litter, were clinging to the tree trunk.

ever, available, as when young nearly as large as rats were found in the second week of February;[1] these must have been born in January. Mr Forrest also mentions the finding of three dead young at the foot of a tree in the latter month. Later litters are found throughout May, June, and into July, but the latest of which Barrett-Hamilton had personal knowledge was on 14th August 1891, when he saw "two quite small young ones, the eyes unopened, which had fallen from their nest in County Wexford."

In early spring an energetic courtship takes place; as usually observed, this consists chiefly of the strenuous pursuit of a coy female by several ardent males. According to Blasius, the males of the nearly allied continental species sometimes fight fiercely with each other for the possession of the females; but we are not aware that this habit has ever been observed in British Squirrels, although males are often far more numerous than females. We have no definite information as to the length of the period of gestation, the Squirrel usually being sterile in captivity; Collett states that Norwegian Squirrels go pregnant for four or five weeks. Lataste was not able to determine whether the ovarian cycle lasted ten days, as in many other rodents, or not; he thought those of Southern Europe to be polyœstrous. On the other hand Heape regards the British Squirrel as probably monœstrous.

The young at birth are blind and naked, with long, straight tails and well-developed claws on their hands and feet. One, not more than three or four days old, has been figured, from a photograph, by Mr W. Evans (as mentioned above, p. 701). They grow rapidly, and leave the nest after they are a few weeks old. The parents are said to be monogamous, and their offspring, according to some writers, remain with them until the following pairing season, the young of two litters even uniting to follow their mother. We doubt the truth of this story, however, and prefer to believe that the experience of Mr Hodgson, who saw the father and mother combining to drive away their young, is more usual.

Although, perhaps, not too careful a mother, the female will guard her young jealously while they are still in the nest,

[1] *Field*, 6th March 1886.

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

HANDS AND FEET OF THE SQUIRREL.

Left Hand.—Fig. 1 in Winter; Fig. 2 in Summer.
Left Foot.— Fig. 3 in Winter; Fig. 4 in Summer.
(Life size.)

and she is not afraid to approach within 4 or 5 feet of a man to scold him vigorously. There is a record of one which twice flew at a birdnester's throat, and cut his shirt with her teeth before she had to retire before superior force. After the retreat of an enemy the mother often removes her young, especially if they have been handled, from the nest to some place of supposed greater safety, bearing them in her mouth, and venturing away from trees and across roads. One young, while thus carried, was observed to occupy a position wrapped round the neck of the dam like a boa. But one which Mr W. Evans caused the mother to drop, and which he sent to Barrett-Hamilton in May 1911, was carried by the skin between the right fore-leg (arm) and the breast. Sometimes a female may be seen playing with and training her babies after they leave the nest, and this forms one of the prettiest sights of the woodlands.

Apart from man, and Martens formerly, the Squirrel does not appear to have many enemies in Britain. Owls, kestrels, and stock-doves sometimes occupy its drey, but probably not until after desertion by the rightful owner.[1] Mr Forrest once found a pair of stoats in occupation—a far more serious invasion. It probably suffers more diminution in numbers during hard winters than from any other causes, and great numbers are said to have perished in Upper Nidderdale during the very hard winters of the early eighties.

The Squirrel is liable to considerable variety in point of colour (*vide supra*, p. 697) the details of which were not properly understood until Mr Oldfield Thomas explained that much that was formerly supposed to be accidental is in reality normally recurrent each season as part of the animal's regular routine of moult and change of coat. This is particularly the case in regard to the cream-coloured tails, which were so long thought to be instances of irregular variation, but which are really characteristic of the animal and the basis of its scientific name.

The fur of the British Squirrel is no longer used in commerce, although at one time it was a favourite decoration for robes, and it is known to have been exported in quantities

[1] For a record of a Squirrel being seized and carried away by a Tawny Owl, see R. W. B. in L. E. Hope and D. I. Thorpe (*Zoologist*, 1912, 184).

from Ireland (see p. 693). That of its continental relative is in request all over the world; formerly large numbers of the grey winter skins — called "Calabar" commercially — were imported into England for treatment by our furriers, but this trade is said to be now almost extinct. It is perhaps fortunate for our species that the excellence of its rabbit-like flesh seems to be unknown to the inhabitants of these islands; the attraction provided by a destructive animal with a saleable pelt and a palatable carcase might well have proved fatal to it.

The Squirrel is well known as a pet, and its appearance and general liveliness must always make it attractive. But, unless taken young, it rarely loses its natural wildness, and it is usually quite sterile. Lataste remarks that it has a good memory for places, but it is full of irritability; he describes the wrath of one which, returning to its cage, found the door closed against it. It is, perhaps, not well to allow such a pet too much liberty, as it is mischievous and always ready to try its teeth on any objects which may come within its reach. However, if it be allowed liberty it forms, in one way, a very good pet for children, as Millais points out; for if at times they are apt to forget to provide their pets with meals, a Squirrel at large will usually contrive to forage for itself.

With regard to the longevity of the Squirrel, captives are said to have lived for nearly eight years; on the other hand Chalmers Mitchell (*P.Z.S.*, 1911, 446) found that of seventy-seven examples of *S. vulgaris* (probably including specimens of the present species) kept at the Zoological Gardens, the average and maximum longevities were only six and twenty months respectively. Many other *Sciuridæ*, however, did better in captivity; twenty-four American Grey Squirrels thus had average and maximum longevities of four and fifteen years respectively.

The Squirrel is used as a part of the arms of a number of English families, and has appeared at least occasionally on sign-boards.

The **American Grey Squirrel** (*Neosciurus carolinensis*, Gmelin), differing from *S. leucourus* by its much larger size and distinctive grey colour has been frequently introduced and liberated in this country during recent years; should it gain a good footing here, as seems not

unlikely, it will prove probably to be a most formidable rival for our native species to face. A good account of the present status of this immigrant in Britain has been given recently by Boyd Watt (*Field*, 12th June 1915, 1044). From this it would appear that Mr G. S. Page, of New York, first liberated five of them in Bushey Park in 1889, but although one seen at Molesey in January 1909 may have been a descendant of these, the stock appears to have died out. They were next introduced, with embarrassing success, in Woburn Park, where "they increased so rapidly that it became desirable to reduce their numbers, and it is stated that about 1000 were killed during a recent winter, and 300 in one week." Steele Elliott, writing to Boyd Watt in July 1914, says that "in Bedfordshire the grey squirrel is numerous in the Woburn district and very common within a few miles of that centre. It has already spread north as far as Bedford, and other equally distant localities in limited numbers." It is now fairly common in Bucks, and specimens have been taken in Hertfordshire. Couples from Woburn were liberated in Regent's Park by the Zoological Society and these, possibly augmented by escaped pets, have greatly increased in numbers and have spread to Hampstead and Highgate. In Regent's Park, although still common, they are said to be "now disappearing, possibly from an excessive production of males" (*Official Guide to the Gardens*, 13th ed., 1915, 72). They are also to be found in Kensington Gardens and in Hyde Park. Other specimens from Woburn were turned out in Kew Gardens about 1905, and these seem to have spread to Richmond Park. At Kew, they are stated to have killed out or driven away all the native squirrels, but beyond this they seem to have caused little damage. On the other hand, the progeny of about thirty, also from Woburn, liberated at Scampston Hall, Rillington, Yorkshire, multiplied and spread so rapidly, and were found to be "so destructive that most of them have been got rid of after three years' constant warfare" (St Quintin, *Country Life*, 17th October 1914, 532). In Dumbartonshire, the species has been present since 1892 (Paterson, *Glasgow Naturalist*, 1912, 136; Boyd Watt, *ibid.*, 1913, 40), and it seems now to be in possession of a strip of country there, measuring about 20 miles long by 5 miles broad. During the winter of 1916-17 one appeared in Dalmeny Park, Linlithgowshire, coming to feed at the pheasant boxes. It was probably an escape from the Scottish Zoological Gardens at Corstorphine, where several have recently been at large (W. Evans, *in lit.*).

Boyd Watt says:—"As regards habits, the grey squirrel, like our native brown species, has many offences laid to its charge, and the judgment upon it is not always so lenient as that given above from Kew Gardens. From Dumbartonshire we are told that it is very destructive to the upper shoots of Scots pines. At Scampston Hall,

Yorkshire, they caused much trouble in the kitchen garden, among the aviaries and poultry runs, and in woods of deciduous trees, and they also raided the gardens for small fruit. Two plantations of sycamores of about thirty years' growth had scores of trees ruined or disfigured—the bark being peeled off the leaders and upper laterals. The verdict of another observer is that they are destructive in gardens; damage the foliage of wych elms and horse chestnuts; consume quantities of walnuts, apricots, and other fruit, and dig up crocus bulbs. Apparently they are not so destructive to fir trees as the native brown squirrel, but are inveterate destroyers of eggs and young birds. In the Zoological Gardens they have been observed taking birds' eggs, or, if the young are hatched, they pull them out, or destroy the nests."

This species is now (November 1918) very common in parts of South Devon. Many individuals are to be seen in the Castle grounds at Exeter. According to Pocock, "it partially hibernates in London parks, or disappears for a few days in cold weather" (art. "Hibernation," *Encycl. Brit.*, 444). The same author states that males predominate in England (*Field*, 27th Jan. 1912, 187).

[Genus CITELLUS.

1816. CITELLUS, Oken, *Lehrb. der Naturgesch. Th.* iii., *Abth.* ii., 824, the genotype being *Mus citellus*, Linnæus; Lichtenstein, 1825; J. A. Allen, *Bull. Amer. Mus. Nat. Hist.*, 16, 1902, 375; Miller.

1825. SPERMOPHILUS, F. Cuvier, *Dents des Mammifères*, 160 (genotype *Mus citellus*, Linnæus); Blasius and most authors.

The Sousliks, Spermophiles, or Pouched Marmots, as they are variously called, enjoy a wide distribution in the northern hemisphere and are probably of Asiatic origin. In the Old World they now range eastwards from Silesia, Bohemia, and Hungary, across Central Asia, but they are not known in Japan; southwards they are represented in Asia Minor, Palestine, and Persia, but do not reach the Himalayan region. In the Pleistocene period they occurred as far west as Denmark and the south of England. Part of the eastward recession of the genus has apparently taken place within the historic period, for Albertus Magnus observed Sousliks in the neighbourhood of Regensburg in the thirteenth century. In North America, Sousliks are found at all altitudes (between sea-level and 10,000 feet in California), from the Pacific Coast

eastwards to the Central United States, and from Arctic Alaska southwards to Central Mexico. Although obviously of ancient standing, no fossil remains of the genus have been found, in either Eurasia or America, in deposits older than the Pleistocene.

The members of the genus *Citellus* may be regarded as degenerate squirrels. They have forsaken arboreal habits, and have colonised the treeless wastes. In these desert places they are strictly earth-bound animals, leading a great part of their lives in their burrows, and subsisting upon coarse herbage, varied with bulbs, seeds, and grain when available. They devour large numbers of insects, and like the true Squirrels betray carnivorous tastes whenever an opportunity presents itself. They form subterranean stores of provisions for use in inclement weather. In warm countries they remain active at all seasons of the year, but throughout the greater part of their range the Sousliks hibernate regularly, remaining in a torpid state in cold regions for a period of six months or more.

The acquisition of such habits has, of course, brought about a good deal of modification in bodily structure. Sousliks are animals of medium size. In general outward form they are essentially of sciurine aspect, although they are more robustly built than are most arboreal squirrels, and have relatively shorter peripheral parts. The fur is thin, coarse, and adpressed. The eyes are large. The ears very small (except in some American forms), clothed with numerous short and fine hairs, but without tufts. Cheek-pouches are present. The limbs are much shorter than in *Sciurus*, and in both hands and feet digit 3, instead of digit 4, is the longest. The vestigial thumb bears a small flattened nail; the other fingers are long, and armed with long, strong, and rather straight claws well adapted for digging. In the foot all five toes possess similarly shaped though shorter claws. The palms and soles, except towards the heel, are naked; on the palm there are five pads, on the sole four, the posterior two being absent; the under surfaces of the digits are annulated. The upper surfaces of hands and feet are well clothed with numerous long hairs which show a tendency to develop as

lateral bristle fringes, especially noticeable along the outer margin of each hand. The tail is much shorter than in *Sciurus*, its length in European species ranging between one-fifth and one-third, instead of being about two-thirds, of the head and body measurement; cylindrical at its base, it is densely clothed with hair; and though far less bushy than in the Common Squirrel, it shows some trace of vertical flattening towards its termination.

The external differences between *Citellus* and *Sciurus* seem for the most part to be directly correlated with the more earth-bound habits of the Sousliks. Change of station has brought with it change of food, and this seems to be the chief factor which has influenced the development of the peculiarities of the dentition and skull in *Citellus*. The incisors are less adapted for gnawing than in *Sciurus*, being relatively weaker, less compressed laterally, and more nearly cylindrical in cross-section. The cheek-teeth are $\frac{5}{4}$ on each side, as in *Sciurus*, $p\underline{3}$ being well developed though small. In form they are clearly more specialized than in the squirrel, and are adapted for the treatment of a coarser diet. In each upper cheek-tooth (except $p\underline{3}$) the single inner cusp and the two cross crests, which connect the inner cusp with the two chief outer tubercles, have become higher relatively and more apparent, forming a conspicuous U-shaped pattern in moderately worn specimens. Corresponding, though less obvious changes have taken place in the lower cheek-teeth. The skull and mandible under the influence of stronger muscles have become relatively robust, and far more massively constructed than in *Sciurus*. Earth-bound habits call for less mental activity than does an arboreal mode of living; the cerebral hemispheres are less developed than in *Sciurus*, and the fronto-parietal region is therefore flatter and much less boldly convex.

The advance of civilization, by bringing the waste places under cultivation, has brought the Sousliks into direct conflict with man at many points in their range. Cultivated plants have a higher food value than the natural herbage; and when man substitutes the former for the latter the Souslik population increases rapidly in numbers. In recent years these animals

in California[1] and elsewhere have thus become numbered among the worst mammalian pests, inflicting enormous losses upon agriculture. These teeming Souslik populations have shown themselves to be liable to plague infection, and in this respect they constitute a very grave peril to the public health in many regions.

Fossil remains of *Citellus* were first discovered in the European Pleistocene by Kaup, who described (*Oss. Foss.* 1839, p. 112, Plate XXV., Figs. 3 and 4) a beautifully preserved skull, which was at first believed to have come from the Miocene *Dinotherium* Sand of Eppelsheim; this specimen formed the basis of Kaup's *Spermophilus superciliosus*. In 1842, Desnoyer and Prévost found abundant Souslik remains, which they referred to *C. citellus*, in the Pleistocene bone-breccia of the caves and fissures of Montmorency. Dr Hugh Falconer in 1859 was the first to detect the genus among British fossils, and in his posthumous *Palæontological Memoirs* (vol. ii., p. 472, 1868) two lower jaws from the bone-caves of the Mendip Hills, and another from the brickearth at Fisherton near Salisbury, are described and figured. To the Mendip specimens Dr Falconer gave the name *Spermophilus erythrogenoides*, but recent study tends to show that this name must be treated as a synonym of *superciliosus*. Since these earliest discoveries, remains of Sousliks have been found in numerous British and Continental deposits of late Pleistocene age. Many specimens were obtained by Dr Blackmore from the Fisherton deposit, while other observers have found remains in the later deposits of the Middle Terrace of the Thames at Crayford and Erith, in the fissure deposits at Ightham, Kent, and in the Langwith Cave in Derbyshire (Cheadle, *Proc. W. London Sci. Assoc.*, 1, p. 7, 1876; Newton, *Quart. Journ. Geol. Soc.*, 50, 1894, pp. 94 and 55, and 1899, p. 422; Mullens, *Derbyshire Archæol. Nat. Hist. Soc. Journ.*, 1913, p. 15.) In 1882 Mr E. T. Newton described (*Geol. Mag.* [ii.] ix., p. 51) some fragmentary remains found by Mr Clement Reid in the "Arctic Freshwater Bed" at Mundesley, Norfolk,

[1] A most valuable account of the Ground Squirrels of California has been published recently by J. Grinnell and J. Dixon (*Monthly Bulletin of the State Commission of Horticulture, Sacramento*, vol. vii., pp. 597-708, 1919).

these were referred provisionally to *S. altaicus* (= *eversmanni*). The Arctic Freshwater Bed lies beneath the well-known Cromer Till, and it is correlated by most geologists with the earlier Pleistocene horizons; the occurrence in it of remains of *Citellus*, a characteristically late Pleistocene genus, is one of the many facts which lead the present writer to correlate the deposit in question with the Third Terrace of the Thames, which is one of the later Pleistocene deposits (Hinton, *Proc. Geol. Assoc.*, xxi., p. 493, footnote, 1910.)

As regards the question of the species represented by the British fossils our knowledge is still incomplete. Dr Forsyth Major studied the material with great care many years ago, and we believe that he concluded that at least two species occur in the British Pleistocene; unfortunately his results were never published. The writer in turn has made some progress with a similar investigation, but has not been able to complete his work yet. In his view also there are two species at least, both extinct, one being allied to the living *C. erythrogenys*, the other more nearly related to *C. eversmanni*.]

ADDITIONS TO VOLUME II

SORICIDÆ.

Since the account of the *Soricidæ* (p. 76) was published, many Shrews from the Hebrides have come to hand, being among the fruits of the exploration of those islands organized by Mr W. R. Ogilvie-Grant. On most of the islands the Shrews found could not be distinguished from the corresponding species inhabiting the mainland of Britain; but the representative of *Sorex araneus* inhabiting Islay proved to be specifically distinct, and we described it in 1913 as a distinct species *S. grantii*. The account previously given may now be supplemented as follows:—

Sorex araneus castaneus (Jenyns).

Specimens indistinguishable from this form were collected by Mr R. W. Sheppard upon the islands of Great Cumbrae, Bute, Arran, and Mull; these were described by us in *Proc. Zool. Soc.*, 1913, p. 823. Similar specimens were collected on Skye by Mr P. D. Montague, and on Eigg by both Mr Montague and Mr D. Anderson. The Shrew found by Mr Sheppard on Jura made some approach in coloration towards the peculiar species discovered on the neighbouring island of Islay.

THE ISLAY SHREW.

SOREX GRANTII, Barrett-Hamilton and Hinton.

1913. SOREX GRANTII, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Abstract Proc. Zool. Soc.*, 13th April 1913, p. 18, and *Proc. Zool. Soc.*, 1913, p. 824; described from Islay, Inner Hebrides (type an adult female collected 26th April 1912, by Mr R. W. Sheppard, original number 76, B. M. No. 18.1.9.19.).

Distribution:—This Shrew is known only from Islay, where a series of twenty-two specimens were collected by R. W. Sheppard during his exploration of the Inner Hebrides (see footnote at p. 422 above).

Description:—This species is distinguishable at a glance from the Common Shrew of Britain by having its dusky upper side much more strongly contrasted with the light colour of the flanks. Its most remarkable character is seen in the dentition. The posterior or fifth unicuspid tooth of the upper jaw (*p*2) is tending to disappear; in more than half of the individuals examined it is lacking, sometimes from one side of the jaw only, but more frequently from both sides. When this tooth is absent, the four remaining unicuspids appear to be somewhat enlarged in compensation.

In size and proportions *S. grantii* agrees fairly closely with English specimens of *S. araneus castaneus*, but averages slightly larger than Common Shrews from the Scottish mainland. The ears, hands, feet, tail, and the quality of the fur are as in the Common Shrew. With regard to colour, adults have the upper side of a deep blackish brown, perhaps darker than the "clove-brown" of Ridgway, the dorsal surface of the head and neck is slightly grizzled with tawny-brown, the under side is silvery or smoky-grey rather than yellowish or brownish as in *S. a. castaneus*, and this colour runs far up the flanks appearing in contrast with the dark upper side. Between the colours of the upper and under parts a narrow, inconspicuous, grey-brown flank-band intervenes, rarely it is "wood-brown," in which case it is more sharply contrasted with the back. The type and another female (collected 23rd April) are moulting into a scarcely less dusky summer coat. The adolescent pelage, judging from specimens collected in May and August, is of a lighter brown colour above, the precise shade being between "seal-brown" and "clove-brown," somewhat as in *S. a. castaneus*, with a flank-band near "wood-brown."

DIMENSIONS IN MILLIMETRES:—

No.	Date.	Head and body.	Tail (without hairs).	Hind-foot (without claws).	No.	Date.	Head and body.	Tail (without hairs).	Hind-foot (without claws).
SPECIMENS FROM ISLAY, CAUGHT AND MEASURED BY R. W. SHEPPARD.									
MALES.					FEMALES.				
73	24th April 1912 .	75	36	13	72	25th April 1912 .	83	37	13
74	24th April 1912 .	77	36	13	*76	26th April 1912 .	75	37	13
77	26th April 1912 .	79	37	13	81	30th April 1912 .	78	36	12
80	30th April 1912 .	80	36	13	96	3rd May 1912 .	77	35	12
82	30th April 1912 .	80	36	13	106	10th May 1912 .	75	35	12
83	30th April 1912 .	80	37	13	157	3rd August 1912 .	75	38	12 juv.
84	30th April 1912 .	78	38	13	158	3rd August 1912 .	80	34	12·5 "
92	2nd May 1912 .	78	35	12	161	5th August 1912 .	78	36	12 "
95	2nd May 1912 .	75	35	12	165	8th August 1912 .	70	38	12 "
98	7th May 1912 .	75	35	12					
100	8th May 1912 .	75	35	12		Average of 18 adults of both sexes	77·3	36	12·6
101	8th May 1912 .	76	36	12					
105	10th May 1912 .	75	36	13					

* Type.

SKULL MEASUREMENTS IN MILLIMETRES:—

	S. a. castaneus. 15 Specimens from Jura, Mull, Bute, Great Cumbrae, and Arran.		*S. grantii.* 12 Specimens.	
	Maximum.	Minimum.	Maximum.	Minimum.
Condylo-basal length	19·0	17·7	19·3	18·2
Malar breadth	5·3	4·8	5·5	5·2
Interorbital breadth	3·9	3·3	3·8	3·5
Width of brain-case	9·6	8·9	9·6	8·9
Depth of brain-case	5·2	4·7	5·2	5·0
Maxillary tooth-row	8·2	7·6	8·4	7·8
p 4 to *m* 3	4·5	4·2	4·6	4·3
Mandible	9·8	9·0	9·9	9·3

The skull agrees in form and size with that of *S. a. castaneus*, but attains rather larger dimensions than skulls of the latter species from northern Britain and the Inner Hebrides.

The teeth agree in form with those of *S. araneus*, but there is no trace of pigment upon the hypocones of the upper cheek-teeth, nor on the protocone of $\underline{m3}$. The posterior unicuspid tooth $\underline{p2}$ tends to disappear, as shown by the following statistics:—

$\underline{p2}$ present on both sides of the jaw,	7 individuals, or	43·7 per cent.
„ absent from one side	„	4	„	25 „
„ „ both sides	„	5	„	31·3 „

When $\underline{p2}$ is absent the four remaining unicuspid teeth appear to be somewhat enlarged.

Status:—By colour and dentition *S. grantii* is clearly differentiated from all European members of the genus *Sorex*. Some of these, such as *S. araneus araneus* and *a. tetragonurus*, have the back as dark, but none shows the conspicuously contrasted sides. *S. grantii* may perhaps be regarded as an insular development from *S. a. castaneus*. It has maintained or acquired slightly larger dimensions than has the latter in the more northern parts of its range. The Islay Shrew has developed a peculiar colour pattern, and is now well on its way to reduce the number of the unicuspid teeth, perhaps because of a tendency to enlarge the anterior members of the series. The Shrew inhabiting Jura, while definitely a form of *S. araneus*, is geographically and morphologically the connecting link between *S. a. castaneus* and *S. grantii*; it has the small size and the dental characters of northern

castaneus, but its colour pattern is modified somewhat so as to make an approach towards that of *S. grantii.*

Neomys fodiens bicolor (Shaw).

From Skye we received five specimens collected in June and July by Mr C. H. B. Grant. These differ in no way from the Water Shrew of the mainland.

RODENTIA.

MURIDÆ.

THE FOULA FIELD MOUSE.

APODEMUS FRIDARIENSIS THULEO, Hinton.

1919. APODEMUS FRIDARIENSIS THULEO, M. A. C. Hinton, *Scottish Naturalist*, November and December 1919, p. 177, described from the Island of Foula ; type, an adult female, collected November 1917 (original No. 5.).

Distribution :—Foula (the Ultima Thule of Tacitus).

Description :—In general external appearance this animal closely resembles typical *fridariensis*, but differs in its smaller size and larger hind-feet.

Size small, the head and body measurement being scarcely greater than in *A. sylvaticus*, and therefore considerably less than in *A. f. fridariensis.* The tail is about equal to the head and body in length when all the specimens in adult pelage are averaged; but it is slightly shorter relatively in the larger or older specimens. The hind-foot is very large, its absolute size being as great as in the St Kilda Field Mouse, *A. hirtensis*, while its relative size is larger than in any other British form. The sole-pads are small as in typical *fridariensis.*

In colour the Foula Field Mouse agrees exactly with typical *fridariensis.* The flanks are dark, the lateral line of demarcation being regular and sharply defined. The ventral surface is of a dull bluish white, without any trace of a buffy suffusion. Normally there is no trace of a pectoral spot. The tail is strongly bicoloured, dusky above, white below. Dorsal surfaces of the feet white.

A direct comparison of the skulls suggests a closer affinity between *A. f. thuleo* and *A. f. grantii* than between the former and true *fridariensis.* The bullæ are as small, and the masseteric plate projects as little anteriorly as in *grantii*; while the brain-case appears to be still broader, rounder and more depressed than in the latter sub-species. In the mandible the coronoid process is very feebly developed as in

each of the other sub-species of *fridariensis*, but its angular process shows no trace of the remarkable elongation characteristic of *f. grantii.* These appearances are borne out by the measurements, which in addition reveal some small peculiarities of the present form. The absolute size of the skull is about as in *f. grantii*, the occipito-nasal length, interorbital width, nasal length and width, and the length of the anterior palatal foramina, are dimensions which tend to be smaller relatively than in the other sub-species of *fridariensis;* while the zygomatic breadth, cranial width, and post-molar length tend to increase in relative value. The rostrum is relatively wider than in *f. fridariensis*, narrower than in *f. grantii;* the masseteric plate is relatively narrower than in *f. grantii*, much narrower than in true *fridariensis;* the length of the tooth-row is nearly as in *f. fridariensis*, distinctly shorter relatively than in *f. grantii.*

DIMENSIONS IN MILLIMETRES:—

No.	Date.	Head and body.	Tail.	Hind-foot.	Ear.	No.	Date.	Head and body.	Tail.	Hind-foot.	Ear.
	MALES.						FEMALES.				
	Skins—						*Skins—*				
1	Oct. 1917	96	..	24·2	16	5	Nov. 1917 (Type)	101·5	102	26	..
4	Nov. 1917	95	94	25·5	..	6	Nov. 1917	93·5	90·5	24·7	..
7	Nov. 1917	87·5	92	26	(juv.)	8	Nov. 1917	103·5	88	24·7	..
9	Dec. 1917	97	91	25	15	B	Nov. 1917	98	98	25	16
11	Dec. 1917	100	93	26	15·5	10	Dec. 1917	104	94·5	25·3	15·5
12	Dec. 1917	98	96	25·5	15·5	13	Dec 1917	91	92	25	14
15	Dec. 1917	90	68·5	25	15·5	14	Dec. 1917	90	90	25	14
	In Spirit—						*In Spirit—*				
	9th April 1917	89	92	23	15		April 1917	81	82	23	15
	9th April 1917	86	97	24	15·5		April 1917	86	83	24	15
	9th April 1917	77	83	23·5	16		April 1917	96	95	23·5	16
	9th April 1917	84	96	25	15		Nov. 1917	80	81	23·5	14
	9th April 1917	83	78	24	15		Nov. 1917	77	77	23	13·5
	Nov. 1917	82	82	23	15·5		Nov. 1917	82	81	22·5	13·5
	Nov. 1917	86	92	25	15		Nov. 1917	81	86	24	16
	Nov. 1917	85	84	24	15		Nov. 1917	91	98	24	16
	Jan.-Feb. 1918	94	..	25	15·5		Nov. 1917	87	..	24	14·5
	Jan.-Feb. 1918	86	87	23·5	15		Jan.-Feb. 1918	90	94	24	16
	Mar.-Ap. 1918	98	95	24·5	16·5						
	Mar.-Ap. 1918	88	95	23·5	15						
	Skeleton—										
2	Oct. 1917	101	..	25·2	16						
	Average of 20	90	90·2	24·5	15·4		Average of 17	90	89·5	24·2	14·9

COMPARISON OF EXTERNAL MEASUREMENTS.

	Absolute (in millimetres).				Relative (head and body = 100).			
A. fridariensis thuleo								
Average of 9 adult males . .	96·5	98	25·1	15·7	100	96·5	26·1	16·3
Average of 10 adult females .	95·8	94·2	24·7	15·3	100	98·5	26·8	16
A. fridariensis fridariensis								
Average of 6 adults	109·5	106·2	24·1	16·1	100	94	22	14·7
A. fridariensis grantii								
Average of 10 adults	101·5	91·8	24	16·2	100	90	23·6	16·9

CRANIAL DIMENSIONS OF *A. f. thuleo.*

(Arranged for comparison with the Table at pp. 538 and 539.)

Number of Skulls examined:—8.	Measurements in millimetres.	Reductions.
1. Condylo-basal length . . . ,, ,, average	23·8 to 25 **24·5**	 100
2. Occipito-nasal length . . .	26·1 to 27·2	108 to 109·5 **109**
3. Zygomatic breadth . . .	13·2 ,, 14·1	54·9 to 56·5 **55·8**
4. Interorbital breadth . . .	4 ,, 4·1	16 to 17·2 **16·5**
5. Cranial breadth	11·6 ,, 12·2	47·8 to 49·2 **48·5**
6. Cranial depth (middle) . .	8 ,, 8·6	32·5 to 34·8 **33·4**
7. Condyle to m^3	11·2 ,, 11·8	46·8 to 48·3 **47·3**
8. Condyle to front of bulla . .	6·4 ,, 6·7	26 to 27·2 **26·6**
9. Nasal length	9·5 ,, 9·9	39 to 40 **39·5**
10. Nasal width	2·4 ,, 2·7	9·75 to 10·9 **10·4**
11. Palatal length	12·5 ,, 13·6	52·5 to 54·9 **54·1**
12. Diastema	6 9 ,, 7·6	28·7 to 30·9 **29·5**
13. Incisive foramina (length) . .	5·5 ,, 6·3	22·8 to 25·6 **23·8**
14. Incisive foramina (width) . .	1·8 ,, 2	7·2 to 8·4 **7·7**
15. Rostral breadth	4·4 ,, 4·8	18·2 to 19·2 **18·7**
16. Masseteric plate (least width) .	2·4 ,, 2·6	9·9 to 10·7 **10·4**
17. Maxillary cheek-teeth . . .	3·6 ,, 3·8	14·4 to 15·7 **15**

History and Status:—The material upon which this sub-species was based consists of thirty-seven specimens collected for Dr Eagle Clarke, chiefly by Mr W. H. Greenaway. Foula lies out in the Atlantic 16 miles west of the nearest point of the mainland of Shetland. It is 3 miles long and 1½ miles broad, with an area of little more than 5 square miles. Rising from the sea in lofty cliffs, which swarm with sea-fowl during the breeding season, its highest point attains an altitude of 1372 feet. Mr Greenaway found the mice, which are termed "Hill Mice" by the inhabitants, on rough ground from the foot of the hills up to 1000 feet above sea-level, and remarks that it is surprising how they survive the storms and trials of the Foula winter.

A. f. thuleo, while quite closely related to the other members of the *sylvaticus* group, is a very clearly defined insular form, best treated as a sub-species of *fridariensis*.

Since the "key" to British *Muridæ*, at p. 377 above was drawn up, our knowledge of the British members of the genus *Apodemus* has greatly advanced. It is now known that of the five species inhabiting these islands, three, *A. sylvaticus*, *fridariensis*, and *hebridensis*, have been differentiated into a number of more or less well-marked insular races or sub-species. *A. flavicollis*, confined to southern Britain, and *A. hirtensis*, inhabiting St Kilda, are each represented by a single form alone. The precise determination of Long-tailed Field Mice from the small islands off the British coast is a matter of considerable difficulty, calling for great patience, skill, and an accuracy of skull measurement and calculation, which in most cases will probably be beyond the powers of an ordinary field naturalist. It is impossible to frame a satisfactory "key" based upon either the external or the cranial characters alone; but the following "key," based upon both sets of characters together, sums up our present knowledge of this most difficult group and will probably assist future investigation:—

"KEY" TO BRITISH SPECIES AND SUB-SPECIES OF *APODEMUS*.

(A) Skulls of adults with post-molar region relatively long; the distance between a condyle and $m3$ equalling 45.5 to 48.3 per cent. of the condylo-basal length, the average value of this dimension never less, and usually more, than 46.23 per cent. of the condylo-basal length.

(*a*) Skull with feeble temporal ridges, and smoothly rounded brain-case; incisive foramina relatively long, their length from 21.9 to 25.5 per cent. (average 23 to 24 per cent.) of the condylo-basal length. Pectoral spot not developed as a collar.

(a^1) Size smaller (head and body about 95, hind-foot about 22 mm.).

(a^2) General dorsal colour brighter, tail longer, averaging more than 95 per cent. of the length of head and body. *sylvaticus sylvaticus.*

(b^2) General dorsal colour darker, with noticeable suffusion of black towards the rump, tail shorter, averaging about 90 per cent. of the length of head and body. . . . . . *sylvaticus butei* (Bute).

(b^1) Size larger (head and body more than 100, hind-foot more than 23 mm.).

(a^2) Head and body 129, hind-foot to 26.5 mm.

Coronoid processes of mandible normal. . . . . . *hirtensis* (St Kilda).

(b^2) Head and body to 115, hind-foot to 26 mm.

Coronoid processes of mandible exceptionally short and slender.

(a^3) Angular processes of mandible normal. Pectoral spot entirely absent or vestigial, tail conspicuously bicoloured, relatively long (averaging 94 per cent. of the length of the head and body.

(a^4) Head and body to 115, hind-foot to 25 mm. . . . *fridariensis fridariensis* (Fair Isle).

(b^4) Head and body to 104, hind-foot to 26 mm. . . . *fridariensis thuleo* (Foula).

(b^3) Angular processes of mandible much elongated. Pectoral spot constantly present, though small, tail not conspicuously bicoloured, relatively short (averaging 90 per cent. of the head and body length). Head and body to 110, hind-foot to 25 mm. . . . *fridariensis grantii* (Yell).

(b) Skull with strongly developed temporal ridges and angular brain-case, incisive foramina relatively short, their length being 19.3 to 21 per cent. of the condylo-basal length.

Pectoral spot large, usually extended laterally to form a well-marked collar. . *flavicollis wintoni.*

(B) Skulls of adults with post-molar region relatively short; the distance between a condyle and $\underline{m3}$ equalling 45 to 47.1 per cent. of the condylo-basal length, the average value of this dimension never more than 46.23 per cent. and usually less than 46 per cent. of the condylo-basal length.

(*a*) Size large (head and body to 112, hind-foot to 25 mm.); dorsal colour not rufous.

  (*a*[1]) Skull slightly smaller (condylo-basal length to 24.7 mm.), ridges feeble, brain-case smoothly rounded anteriorly.

    (*a*[2]) Ventral surface dark, pectoral spot often lengthened into a median longitudinal thoracic and abdominal streak. . . . . *hebridensis hebridensis* (Lewis).

    (*b*[2]) Ventral surface silvery, pectoral spot absent or feebly developed. . . *hebridensis maclean* (Mull).

  (*b*[1]) Skull larger (condylo-basal length to 25.5 mm.), ridges comparatively strong, brain-case angular anteriorly. Belly silvery; pectoral spot evident. . . *hebridensis hamiltoni* (Rum).

(*b*) Size smaller (head and body to 95, hind-foot to 23 mm.). General dorsal colour rufous. Belly silvery; pectoral spot scarcely developed. . . . . *hebridensis cumbrae* (Great Cumbrae).

GENUS RATTUS (=*Epimys*).

On p. 575, *et seq.*, *Epimys* Trouessart is used as the generic name of the true rats. Hollister (*Proc. Biol. Soc.*, Washington, 1916, **29**, p. 124) has pointed out, however, that Fischer in 1803 (*Das National Museum der Naturgeschichte zu Paris*, Bd. 2, p. 128) used *Rattus* (misprinted *Ruttus*) for this purpose validly. The name *Rattus* must therefore supersede *Epimys*, a regrettable though quite unavoidable change. Hollister thought that *decumanus* (i.e., *norvegicus*, was the type species of Fischer's genus *Rattus;* but Thomas (*Ann. Mag. Nat. Hist.*, 18, p. 240), and Hinton (*Journ. Bombay Nat. Hist. Soc.*, 23, p. 59) agree that Fischer took *rattus* and not *norvegicus* as the genotype. The correct technical names of the species occurring in Britain are now therefore :—

1. *Rattus rattus*, with its sub-species *r. rattus*, *r. alexandrinus*, and *r. frugivorus*.
2. *Rattus norvegicus*.

1. *Rattus rattus.*

Since the account, at p. 592, of the **Geographical Variation** of this species was published, the house rats of India, Burma, and Ceylon have been studied by Hinton (*J. Bombay N.H.S.*, 28, pp. 59-88, 384-416, 716-725, 906-918, 1918 and 1919). This work was based upon the rich material gathered during the mammal survey of India, undertaken by the Bombay Natural History Society, as well as upon the collection in the British Museum. In the various Mammal Survey Reports published by Wroughton and others in the *Journal* cited, the Indian house rats were listed as "*Epimys rufescens*" when they had dusky bellies, and as "*Epimys rufescens*, var." when their under parts were white. That this difference in colour had some geographical value had long been apparent; and it was thought that the white-bellied and dark-bellied types might belong to two distinct sub-species or even species. To test this possibility was one of the chief objects of Hinton's work. The results arrived at may be briefly summarised as follows:—

The common Indian house rats, whatever may be their colour, are all referable to *R. rattus*; but the forms described as *R. nitidus* Hodgson, and *R. vicerex* Bonhote, about the status of which there has been controversy, are distinct species of the *R. rattus* group.

Like their European representative *R. r. frugivorus* in the Mediterranean region, the Indian white-bellied forms of *R. rattus* ("*Epimys rufescens*, var." of the Survey Reports) are essentially wild animals, often living out of doors in jungle and woodland in the most remote rural districts of India, Burma, and Ceylon. As wild mammals they show a definite geographical variation, so that many sub-species have now to be recognised. Descriptions of these are given in Hinton's paper.

With regard to the dark-bellied Indian house rats the case is different. Wroughton (*Journal* cited **23**, p. 474) had already put forward the view that the white-bellied forms of *R. rattus* in the Indian region represent the primitive wild form of the species, while the dark-bellied types have developed from these wild forms in response to changes of environment which have ensued upon the species becoming partly or wholly commensal with man,—the darkening of the under parts in the least modified of the Indian races, no less than the darkening of the back in the wholly parasitic *R. r. rattus*, being the outward indication of domesticity. These dark-bellied forms ("*E. rufescens*" of the Survey Reports) are in great measure restricted to the districts of India which possess substantial houses; and they are far less frequently caught out of doors than are the white-bellied races. Series of dark-bellied specimens from single localities or colonies are frequently very uniform in appearance and structure among themselves; but when series from different, though sometimes neighbouring localities are examined, an enormous range of variation

is found. This variation, when not purely individual, proves to be of a colonial character and has little geographical value. It is therefore not possible to define sub-species or geographical races among the dark-bellied forms. In some districts, as in Kumaon, N. W. India, such rats seem to have little or no connection with the local white-bellied forms, in other places they differ from their white-bellied companions merely in colour and to a trifling extent in skull—the cranial differences being susceptible of physiological explanation; finally, in still other districts, the difference is purely one of colour, and even that sometimes breaks down. One may conclude therefore that the dark-bellied rats are of diverse origin; some seem to have been produced, in the localities where they are now found, from the local white-bellied race; others have found their way to their present habitations from other more or less remote districts of the country, or even from abroad; and lastly, many are doubtless to be regarded as the mixed descendants of both native and imported stocks.

The work now done, incomplete as it is, affords a perfect explanation of the conflict of opinion, with regard to the value of the species and sub-species recognised in recent zoological literature, which has arisen between systematic zoologists, and observers like Hossack and Lloyd studying rats in connection with plague in large towns or ports like Calcutta or Bombay. In such places it is hopeless to attempt to disentangle the history of the rats, for the urban rat population is a motley horde, representing the progeny of the truly native rats crossed with the descendants of old wanderers and with newcomers not only from the neighbouring hinterland but from all parts of the world. It is only in the rural districts that we can expect some measure of success to crown such efforts.

THE SMALL-MAMMAL PROBLEM.

During the war a great increase in the rat and mouse population of Britain became visible both in town and country. This rapid growth gave rise to alarm, which culminated in the passing of the "Rats and Mice (Destruction) Act, 1919." The abnormal increase was due to a combination of two entirely distinct sets of causes. Firstly, neglect and active folly pursued throughout a long course of years in the pre-war period, had together brought the rat and mouse resistance of the country down to a low degree. Thus few of our older buildings were, or have been made, rat-proof; and the stores of foodstuffs, and other materials attractive to rodents, in our warehouses, markets, and shops, remained without adequate

protection from the ravages of rats and mice. Our waterways, sewers, and drains formed highways for, and harboured, hordes of Common Rats, which made their way, chiefly by means of unprotected drain-pipes, into the basements of adjoining buildings. In the towns, the underground kitchens, bakehouses, and other places in which human food was prepared, were regularly visited by droves of rats entering from the sewers and bringing filth and corruption into contact with the food of the citizens. Neither owner nor occupier of dilapidated rat-ridden property was under any obligation to repair and disinfest such premises; while many Local Authorities provided secure quarters and nourishment for the rat population by permitting the formation of great mounds of refuse upon waste lands in the vicinity of towns and docks. In rural districts, stackyards and farm buildings of all kinds were allowed to be entirely without protection. Still worse, in the interests of intensive game preservation and poultry farming, to the great detriment of general agriculture, every creature that could possibly be supposed to be inimical to game or poultry was (and still is) treated as "vermin." Summing up, we may say, that in 1914 we were negligently providing accommodation and nourishment for a vast rat and mouse population, although well aware that these rodents inflicted upon us a colossal annual financial loss and brought grave peril to the health of the community. In the towns, in order to keep the numbers of our guests in some control, we had to depend naturally upon the continuous employment of a great body of ratcatchers and a considerable annual expenditure upon the means of rat and mouse destruction. In rural districts we were no better off, for by allowing the countryside to be depleted of the natural enemies of rodents, the work of limiting the numbers of rats devolved to a large extent upon the gamekeeper and ratcatcher.

Secondly, the abnormal conditions which ensued upon the outbreak of war greatly aggravated the position, evil as it was in the summer of 1914. The accommodation available for rats and mice grew rapidly with the establishment throughout the country of vast camps and stores, housed for the most part in buildings of a fragile and temporary

character; hundreds of new factories (with dwellings for work-people), new docks, and even new towns came into being in response to military requirements, and every addition of that sort meant new quarters for rats and mice. In order to feed our forces and ourselves, enormous quantities of foodstuffs were imported, and warehoused in all parts of the country; many thousands of acres, previously untilled, were now brought under cultivation, and in laudable endeavours to increase the food resources of the nation, all classes devoted themselves to the cultivation of allotments and the rearing of poultry and rabbits. Such efforts greatly increased the food supplies accessible to rats and mice. As the war developed, labour was steadily diverted to military purposes; scavenger, rat-catcher, and gamekeeper disappeared. Regulations made under the Defence of the Realm Act prohibited the use of foodstuffs for the purposes of rat and mouse destruction. By such means we gave rats and mice shelter, sustenance, and security on a scale of unprecedented lavishness. The high fecundity of these creatures enabled or forced them to take quick advantage of these favourable conditions, and we were soon faced with grave peril. With the cessation of the work of the gamekeeper, the native carnivora began naturally to recover some of their lost numbers; but their relatively low fecundity, and the fact that they had been brought so low by pre-war vandalism, prevented them from increasing in due proportion with the increasing numbers of the rodents. Besides, the accommodation for carnivora was considerably decreased by the war conditions; not only were new towns and factories built in formerly wild districts, and waste lands brought under cultivation, but much of the woodland, the natural stronghold of most carnivora, was destroyed.

The rapid growth of the rat population caused public inconvenience and alarm; heavy losses were inflicted upon individuals and upon the State by the depredations of these animals, and it appeared not improbable that they were largely instrumental in disseminating various epidemic diseases then ravaging the civil and military population. Towards the close of 1917 considerable outcry against these pests arose; and was met by the issue of emergency regulations by Government

departments. The Ministry of Agriculture and Fisheries formed a special Rats Branch, and in 1919 the emergency legislation was embodied, extended, and permanently established by the Rats and Mice (Destruction) Act.

In view of the importance of this matter, and of the expense and not infrequent hardship, which the proper administration of this Act will entail, it will perhaps not be thought out of place if we discuss some scientific considerations bearing upon the rat and mouse problem. We will in the first place deal with some points of interest in connection with the destruction of rats and mice. Secondly, we will try to show that the problem of the rat and mouse is only one branch of a far greater problem involving not one or two species merely but all small mammals. That greater problem must be solved in the near future, for with the growth of civilisation it confronts us in all parts of the globe. Even so far as Britain is concerned, the Act does not solve the problem, although undoubtedly it is the first step in the right direction yet made by the legislature.

The Act aims at bringing about a great reduction in the rat and mouse population. It imposes certain obligations upon, and gives certain powers to, County and Local Authorities, the general administration of the Act being entrusted to the Ministries of Health and Agriculture. County Rat Officers have been appointed for the purpose of putting the Act into practice; and the owner or occupier of rat-infested premises is now compelled to free his premises from infestation and to put his house in order. All this is good and should lead to a rapid improvement in existing conditions; and from the Rat Officers we may hope to obtain a great deal of information.

The high fecundity of our parasitic rats and mice makes it very difficult or impossible to exterminate any one of these species by methods of active destruction alone. The best information, at present at our disposal, concerning the breeding rate of any of the three species inhabiting Britain is that furnished for *R. norvegicus* by Petrie and Macalister.[1]

[1] Petrie and Macalister in "Reports and Papers on Suspected Cases of Human Plague in East Suffolk and on an Epizootic of Plague in Rodents." *Reports to the Local Government Board on Public Health and Medical Subjects*, N.S., No. 52. London 1911, p. 58.

In 1911, between 16th January and 14th February, these observers examined 6071 individuals, collected in Suffolk and Essex during the period specified. Of these rats 3273 were males, 2724 females, and of 74 the sex was not recorded; 290, or 10.6 per cent. of the females were pregnant, the average number of embryos in each being 9. Had the count been made in warmer months of the year a higher percentage of pregnant females would doubtless have been observed. It is clear from these statistics that many more rats are born than can possibly survive; limitations of space and food ensure that a large proportion of all the young born must perish before attaining sexual maturity. If from any cause the mortality among the adult rats is increased, competition for food and space is diminished and the chances possessed by the young of reaching sexual maturity are increased proportionately. From the data cited it is possible to form an idea of the maximum monthly loss which the rat population can sustain without fear of extinction. We are thus able to gain a rough notion of the magnitude of the task of rat extermination, and to realize the necessity of following up each campaign by another. For, assuming Petrie and Macalister's results to apply throughout Britain at all seasons, it may be shown that, provided there is sufficient food and space, the rat population can double itself in about seven years, even although we assess the monthly mortality among the sexually mature individuals at 10 per cent., and assume that 75 per cent. of all the young born perish without reaching sexual maturity.[1] High mortality among the young can only be

[1] The calculation upon which this statement is based is as follows:—Of 5997 rats 3273 or 54·5 per cent. are males, 2724 or 45·5 per cent. females. Of the females, 290 or 4·85 per cent. of the total stock give birth to litters of 9. Assuming a mortality of 10 per cent. among adults and 75 per cent. among the immature in each month, R in the following equation represents the number of rats living in any given month for each 100 rats living in the next preceding month.

$$R = \overset{\male}{54{\cdot}5} + \overset{\female}{45{\cdot}5} - 10 + \frac{4{\cdot}85 \times 9}{4} = 90 + 10{\cdot}91 = 100{\cdot}91.$$

Applying the formula given for compound interest, where

$$t = \frac{\log. a - \log. p}{\log. R}$$ we find that the rat population doubles in 79·5 months.

The equation shows that, with the rates of mortality assumed, the rat population would increase if 4·45 per cent. of the population gave birth to young in each month; while if less than 4·4 per cent. gave birth to young it would decline.

maintained by the pressure of competition or by extreme persecution; the greater the loss inflicted upon the rat population the more rapid the rate of recovery.

Rodier, dealing primarily with the rabbit pest in Australia, has advanced an ingenious plan for controlling the numbers of rodents. He thinks we should aim at producing a vast excess of males. Rabbits, rats, or mice should be trapped alive; the females should be killed and the males given their liberty. By this proceeding a great disparity in the numbers of the sexes will be produced in due course, and a keen competition will arise among the males for the possession of the surviving females. The males will fight each other continuously, and they will, at all times, relentlessly pursue and harass the females. The nursing does will be unable to rear their families, and any species attacked by this system will become rare if not extinct. The present system of indiscriminate trapping and poisoning, according to Rodier, has a directly opposite effect; it ensures the destruction of the surplus males, and results in fertile unions for all females.

Rodier's scheme has been advocated recently by Mr G. Jennison,[1] who has been experimenting for some years at the Manchester Zoological Gardens. He states that "our present system of destruction helps the rat in the struggle for existence. The more rats killed, the more food for the remainder; the more males killed, the greater the chance for the doe to breed quietly and raise her offspring. These two facts together neutralise all the good effects of indiscriminate slaughter. The rats can be reduced quickly to a certain point beyond which it is almost impossible to make further progress, and from which they soon reach their former numbers if at all neglected, *e.g.*, Copenhagen caught 100,000 in four months, 8th August to 8th December 1904; they could still catch 99,000 in the three months of July quarter 1908, under the new rat law." Applying the Rodier system to the Bellevue Gardens, Manchester, Jennison reduced the number of rats caught there from about 34 per month at the end of 1915, to 18.5 per month in the first six months of 1920. He says "the best plan for rat destruction appears to me plain.

[1] G. Jennison, "Rat Repression by Sexual Selection," *J. R. San. Inst.*, xli., 358.

Where rats are very numerous, apply twelve months of intense slaughter, which will bring the problem within manageable limits; then apply the Rodier system. Its great merit is the lengthy period of neglect that an area well in hand can sustain before becoming, if it ever does become again, a nuisance; its defect is solely the difficulty of execution. Rat-poisoning must cease, and rat-killing as a sport must be banned, though a careful man may shoot with safety rats carrying food, as the does alone perform this duty."

Mr E. Read, chief of the Rats Branch of the Ministry of Agriculture and Fisheries, has been kind enough to inform us of a method, discovered by the work of his department, by which the Rodier system can be applied in a practical and wholesale manner, without the initial trouble of capturing the rats alive and determining the sexes. During the earlier winter months, *e.g.*, November, poisoning with a preparation of liquid extract of squill and milk has been resorted to, and many thousands of rats have been killed in all parts of the country by this means. Of the total number killed in this way at this season, no fewer than 85 per cent. were females, the milk proving to be an irresistible bait for the does nursing families at the onset of the inclement season. The Rodier system deliberately and generally applied could show no better result than this, because even with it, accident and error in the determination of sex would certainly lead to the death of many males. From this experience it would appear that active rat destruction should take place chiefly in the winter months when the does are hard pressed; the other months should be used chiefly for preventive work such as rat-proofing.

Scientific study confers a measure of foresight, and it is often possible to predict many of the consequences which must flow from current actions. The small-mammal problem is one of the things pre-eminently susceptible to treatment by intelligent anticipation, and with our knowledge and experience, we certainly ought not to be content with merely devising expedients to cope with the difficulties of to-day, heedless of the perils of to-morrow. Given sufficient determination, money, and patience, we might, in the course of time, succeed in exterminating both species of rat and the House Mouse in

Britain. But such success would not bring with it the real fruits of victory; the small-mammal problem would still remain, demanding urgent solution from the inhabitants of this island.

The problem in question has arisen in this, as in all other countries, as one of the many far-reaching consequences of human interference with the working of the "Balance of Nature." Small mammals, like humanity, feel the pinch of cold and hunger, or the pain of heat and thirst; accordingly they welcome shelter from the weather, food and drink in plenty, and security from their foes. Wherever man in the presence of a wild mammalian fauna, contrives a shelter for himself, his goods, or his domestic animals, there will always be a greater or less number of species quick, if not prevented, to enter into an uninvited partnership with him, sharing his joys and, it may be, increasing his sorrows. Among mammals, no doubt, murine rodents show the quickest appreciation of the benefits conferred by unintentional human benefaction; and they are generally the first wild mammals to become commensal with man. But the power to force an undesired alliance upon careless humanity is not restricted to the Muridæ among rodents, nor to the rodents among mammals; it is shown in various degrees by such different Orders as the Chiroptera, Insectivora, and Carnivora. Individual species belonging to these other Orders like *Pachyura gigantea*, the Indian Musk Shrew, may become thoroughly parasitic, and acquire greatly extended distributions in consequence.

Among Muridæ, at the present time, three species alone claim so much attention because of their parasitic habits, that there is danger of our overlooking the claims of their rivals in such a connection. Two of the three, the House Mouse and *R. rattus*, had the good fortune to live originally in the cradle of civilization. Possessing habits which permitted a close association with humanity, they entered the earliest houses, and with civilized man they have spread over the greater part of the globe. The third species, *R. norvegicus*, is a native of a more remote and desolate region; widely different in habits from either House Mouse or *R. rattus*, and habitually shunning the presence of man, it had to wait long for an opportunity of invading Western Europe. Once introduced, it made rapid

progress, finding congenial surroundings in the cellars and drains of the towns, and along the banks of the rivers and canals. As described above (p. 583), the coming of *R. norvegicus* to Britain led to the almost complete extinction of *R. rattus* as an inland inhabitant of this country during the eighteenth and nineteenth centuries. Quite recently, however, *R. rattus* has been recovering its lost ground—a fact of importance in connection with the argument now being presented.

When *R. norvegicus* arrived in Britain, in the early part of the eighteenth century, it found *R. rattus* in complete possession. At that date rat-proofing was not attempted, and the rat population in the towns was kept in control by the ratcatcher. So far as human intervention was concerned, both species were upon terms of equality. In these conditions, favoured by its own constitution and character, *R. norvegicus* triumphed and *R. rattus* was defeated. In the later part of the Victorian period it was difficult to procure any example of the latter species away from the vicinity of the docks. Towards the end of the nineteenth century, and in later years down to 1915, great changes took place in many of our cities. Many of the older houses were demolished, and upon their sites were erected buildings of stone, characterised by a lavish use of cement in their foundations, as well as by the possession of perfect sanitary appliances and well-guarded drains. These buildings, particularly the most modern examples, are for the most part proof against rats seeking entrance through basements, and therefore they remain free from infestation by *R. norvegicus.* But *R. rattus* is primitively an arboreal species; and telephone wires and cables now extend from building to building, bridging the streets. The chief waterside colonies of *R. rattus* to be found in our ports are situated for the most part in lofty, solidly-built warehouses. These rats issue from the upper floors of the dockside premises, and pass along the telephone wires to the roofs of other buildings. Roof kitchens are among the improvements of the modern structures, and *R. rattus* soon invades them, effecting an entrance from the roof through skylight, window, or ventilator. In this way new colonies are formed at increasing distances from the docks, and in many towns, as in London, the species

is regaining ground lost in the preceding two centuries. Here we have an excellent example of the working of the Balance of Nature even in the heart of a great city. So long as *R. norvegicus* and *R. rattus* compete on level terms, in a temperate country, the former must win; but if the former be denied access to a building which remains open in some way, and attractive to *R. rattus*, the latter will enter and thrive in its security from competition.

There was a time when Britain possessed no member of the genus *Rattus*. At that date the House Mouse, which arrived from the East possibly with the Neolithic or Bronze Age people, was in full possession of the dwellings. On one view of the evidence, the fact that the House Mouse has developed special insular forms, like those of St Kilda and the Faroes, might be cited as proof that *Mus musculus* had already made a conquest of human households and baggage at the dates when the first wanderers landed on those remote islands. Be that as it may, there is no reason to doubt that before the arrival of the Black Rat, the House Mouse filled all the accommodation available for parasitic Muridæ in Britain, and if rats had not arrived in Britain to claim their present large share of the existing accommodation, all, in so far as it is suitable to *Mus musculus*, would now be filled by House Mice. The presence of a rat population keeps the numbers of mice in strict and proportionate control; what the House Mouse population of the country can be at any given moment is limited by the size of the rat population among other things.

There are still some countries not yet colonised by *R. rattus* or *R. norvegicus*, and where the House Mouse is unknown. Yet in these countries the small-mammal problem is felt just as acutely as in the centres of European civilization. Native Muridæ swarm in the houses of Central Africa, and during recent years elaborate, costly, but fruitless attempts have been made to exterminate these pests there. In those parts of America where the exotic *Murinæ* have not yet obtained a footing, the native *Cricetinæ* play the parts of house mice and house rats. Nor need we go so far afield; many of our own country houses are infested by *Apodemus*, more rarely by *Evotomys*, and even on occasion by the exclusive *Arvicola amphibius*.

Station, habits, and food, no doubt, are regulated for each species to a considerable degree by the constitution of the species; but often, changing circumstances betray the fact that the familiar and apparent limitations bounding the range of individual choice are not those imposed upon a species by any inelasticity of its own constitution, but are such as result from extrinsic influences such as the competitive presence of other creatures. Exterminate a species from a given area, and many different claimants for the vacant place rapidly appear; no one of those claimants, perhaps, will be able to fill the whole vacancy, but between them all it is soon filled. In each case the driving power comes from within; "increase and multiply" carries "colonize or perish" as its corollary; few individuals die voluntarily.

It is, of course, necessary to-day to wage an active war against both species of *Rattus* and against the House Mouse, not only throughout Britain, but aboard the shipping in our ports. The numbers of these rodents living in our midst are far too great, putting the public health in peril and occasioning serious economic loss; they must, therefore, be reduced. But mere extermination of these species is not, and cannot be, a solution of the small-mammal problem. The mere killing of a great number of individuals relieves the survivors from much active competition for food and space, and ensures a more rapid rate of breeding. The killing of an old male rat at once provides food and space for three or four immature rats that otherwise would have perished. Extermination of *R. norvegicus* must inevitably result in better chances for *R. rattus* in the struggle for existence. Extermination of both species of rat must enormously increase the space and food available for *Mus musculus*. The elimination of these alien parasitic Muridæ must inevitably bring us into conflict with our native members of the family. That the latter, hitherto, have not to any large extent invaded our houses and towns is due solely to the fact that the alien species are already in possession, and have been, so far, strong enough to keep the native forms outside in the cold. The extermination of all Muridæ, native and alien, from Britain would merely disturb the Balance of Nature in favour of other

groups of small mammals, and most probably in favour of many other organisms also. An attempt to solve the small-mammal problem by purely destructive methods is doomed, therefore, to failure; it opens a vista of endless strife with the organic world, fraught possibly with great danger from unforeseen consequences, infinite expense, and no satisfaction.

Small mammals in themselves are not evil things; on the contrary they play a great part in that complex natural mechanism by which all animals and plants are brought into relation with each other; a mechanism in which every living thing has to do its exact share of the work of keeping the face of the earth variegated and happy. Aware of this fact, and of the complexity of the relations subsisting between each and all species, it becomes impossible to assert with confidence that we can afford to dispense entirely with any single species now forming part of the British fauna. It is only when man, disturbing the Balance of Nature for his own ends, unduly favours one species or group of species, that evil results from small mammals. "Noxious species" have become "noxious" in consequence of our own carelessness and stupidity; to eliminate them, and to remain careless and stupid, is merely to invite other species, at present innocent, to stray and become "noxious" in turn.

Considerations of health and economy forbid all thought of leaving the small-mammal problem unsolved. Simple destructive methods alone, as shown above, will not solve it. To devise adequate preventive methods seems therefore to be the only course now left open to us; in such methods alone can we hope to find a real solution to the problem. The most serious objection to preventive methods is their cost. To put in practice a vast scheme of rat and mouse proofing will cost an immense sum of money, and it will tax the national energy and resources for many years. A cheap remedy for ills springing from the negligence of two thousand years is, however, more than we can reasonably expect. Every farthing spent on prevention will produce permanent benefit; while sums spent upon mere destruction of rats and mice can procure no more than temporary relief.

The preventive methods contemplated are of two kinds.

Firstly, we must learn to deny unnatural shelter and food supplies to small mammals. Secondly, we must not give them an unnatural security from their enemies in the open country.

All new buildings in town or country should be of rat-proof construction; especial attention should be given to buildings destined to house great quantities of foodstuffs. Among existing buildings, those which are rat-ridden should either be disinfested and repaired, or else they should be demolished. Many a house at present infested could be cleared of rats and mice, and made practically safe from further invasion were two or three drains properly sealed, or a broken ventilator or so repaired. "Shelter" and "food," of course, must be construed liberally; for the dump of rubbish standing for years on a piece of waste ground, or the unguarded sewer and its filthy contents, may provide small mammals with both palatial accommodation and regal fare. At all times special attention should be given to the protection of human food supplies, to stables and other places in which domestic animals or their foodstuffs are kept, and to the collection and disposal of garbage. There are many ways of protecting cornstacks and the like from the attacks of rodents, and the adoption of one or other of such means should be insisted upon.

The effects of all such preventive measures should be carefully watched and studied. As described above, many modern buildings, successfully resisting the attacks of *R. norvegicus* from below, have been invaded by *R. rattus* from above. Had the telephone cables been provided with rat guards, no trouble with *R. rattus* would have ensued. At every step, therefore, we must be on the alert, lest in shutting the door to one species, we open a way for another.

Although we can and should protect such things as farm buildings and cornstacks, it is impossible to make the open fields rat or mouse proof. And if we were able to do such a thing, it might be very far from advantageous to attempt it. But Nature has provided the best means of keeping the rodent population in control in the open country—a means which will not fail us if we do not seek its destruction, and if we do our part by denying, as far as may be, all unnatural

shelter to small mammals. Our rural rodent population will then be kept within bounds by the action of the weather, and of its chief enemies, the carnivorous mammals and birds. It is of vital importance, to general agriculture and to the nation at large, that we should preserve a sufficiently strong carnivorous element in our fauna. We possess no better friends than the Weasel, the Stoat, our native Owls, and the Kestrel, since small rodents form the staple food of all these animals.

But our carnivora are systematically persecuted throughout the country and brought to the verge of extinction. The game preserver endeavours to rear annually a stock of game far in excess of the natural capacity of his estate, hoping each season to produce a great surplus which he may destroy for pleasure and profit. This cannot be done to so large an extent in the presence of carnivora as in their absence; carnivora will help themselves to part of the surplus produced. Therefore carnivora are proscribed; and the preserver and his keeper ruthlessly destroy that, which, in the national interest, should be carefully protected. It is said that the rearer of poultry will suffer if carnivora become abundant. But it must be remembered that carnivorous tastes are not peculiar to the Order Carnivora or to the Birds of Prey; the development of such a taste is often a mere matter of opportunity, and the Common Rat frequently shows itself to be as carnivorous, and as destructive of life as any species of true carnivore, its crimes being often laid at the doors of other species. If the poultry farmer, the fancier, and the game preserver protect their stocks from the ravages of the Common Rat, they will have little to fear from the much hated carnivora. Everything in this world has its price, and carnivora do not form an exception to that rule; we need them and must pay the price, but whether we buy cheaply or dearly depends entirely upon ourselves.

histories of very many others, which were formerly little known, have been fully elucidated, while, speaking generally, an immense increase in our knowledge on such important subjects as Migration, Distribution, Habits, Nidification, Plumages, has accrued: And lastly, a new and important branch of study has been instituted—namely, the recognition of the various Racial Forms or Subspecies exhibited by certain birds in the British Islands, on the Continent, and elsewhere.

A great advance has also been made towards a more satisfactory system of classification of the Aves—always a difficult subject—and this necessitates departures from the older views.

To bring this Standard Work thoroughly abreast of the most recent knowledge in all these departments is the object of the present work.

It should be remarked that while it is not intended to go fully into Synonomy, yet, where changes of nomenclature have been necessary in order to conform with the Law of Priority—the only method by which complete uniformity in nomenclature can ultimately be attained—the names used in the Fourth Edition of Yarrell's "British Birds" and in Saunders' "Manual," and the Trinomial Names of the British Racial Forms, and of those occurring in Britain as visitors from the Continent, will be quoted, as will also the Original Name under which the species was described.

In requesting Dr Eagle Clarke to undertake the duties of Editorship, the Publishers desire to make it known that they are acting under the advice of the late Mr Howard Saunders, who placed all his collected notes for a New Edition at Dr Eagle Clarke's disposal for this purpose. That Dr Eagle Clarke is eminently fitted for the work is well known to all who are interested in ornithological science. Through his investigations of the subject, and contributions to its literature, he has long been recognised as one of the foremost authorities on all that relates to British birds. He has studied our native birds in many portions of the British Islands, and has visited a number of bird-haunts in various parts of Europe in order to become acquainted in their Continental homes with the visitants that seek our shores.

On the important matter of the Migrations performed by British Birds, Dr. Eagle Clarke's knowledge is unrivalled—a material fact, when it is called to mind how little has been said on this most important subject in any published History of British Birds.

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Oliver and Boyd, Printers, Edinburgh.